

PROJECT SPECIAL PROVISIONS
CITY OF ALEXANDRIA VIRGINIA ITS INTEGRATION PROJECT
PHASE III
July 27, 2020

UPC 106563



City of Alexandria
Transportation & Environmental Services

Project Special Provisions

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1. GENERAL REQUIREMENTS

1.1. DESCRIPTION

(A) Summary of Work

The goal of the City of Alexandria's ITS Integration Project is to construct an urban transportation management system that will improve mobility in Alexandria through sound engineering, design, and technology implementation. This is a multiphase effort of designing and installing flexible and scalable infrastructure that will accommodate existing and future technologies. This document describes the requirements of Phase III of ITS Integration Project.

The purpose of Phase III is to add CCTV cameras to the closed-circuit television (CCTV) system, upgrade City's Traffic Management Center (TMC), and improve traffic signal operations for the City of Alexandria, Virginia.

Phase III of the project will integrate additional CCTV cameras with the existing Bosch Video Management system (BVMS) for the City. Previously installed cameras are fully digital and IP addressable using standardized video compression (H.264) and standard control/status interfaces, such as Open Network Video Interface Forum (ONVIF) and National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) providing universal interchangeability.

This Phase will also link several existing traffic signal controllers to the traffic signal management system using City owned fiber optic cable. Passive optical network (PON) technology will be used for point to multipoint transmission between the traffic signal system server and controllers in the field. A PON consists of an optical line terminal (OLT) at the TMC and an optical network terminals (ONTs) at each of the selected intersections. The PON system expansion installed with this project shall be fully compatible with the City's existing pilot PON system. The existing PON system architecture utilizes a Calix E7 ONT at the TMC communicating with Calix 716GE ONT in the field.

Alexandria City officials have released links to real-time local traffic cameras and sensors to help commuters assess traffic before getting in their car. Real time data includes traffic cameras (*powered by trafficview.org*), traffic sensor data (*powered by blyncsy.com*) and traffic street map (*powered by Google.com*). City's GIS Division is working with City's IT Department to prepare web based application that will bring data from different sources onto a conditions map. The real-time condition map will provide a means to consolidate and process data from Automated Vehicle Location (AVL) systems, traffic sensors, a CCTV camera system, a central traffic system, signals with transit priority, lane closures, pavement temperature sensors, flood sensors, and weather data from NOAA.

In Phase III, video wall will be upgraded, and new monitors will be installed at the TMC to display video images from CCTVs, and traffic data from other sources, GIS data and signal system data on a conditions map.

This project's primary components include:

- Installation of single-mode fiber-optic cable and conduit communications network. New fiber optic cable along with the conduit will be installed along Duke Street between S. Walker Street and S. Reynold Street, and VanDorn Street between Duke Street and Edsall Road. A new fiber optic cable will be installed in existing conduit along Van Dorn Street between Eisenhower Avenue and Edsall Road, King Street between Beauregard Street and

Dawe's Avenue, Seminary Road between Beauregard Street and Dawe's Avenue, and Braddock Road between Van Dorn Street and Howard Street, and Howard Street between Seminary Road and Braddock Road. Fiber communication system will expand the infrastructure for the City's ATMS network, as well as provide communications infrastructure to other internal departments within the City;

- Addition of 11 CCTV cameras to the video surveillance system
 1. Van Dorn Street and Stevenson Avenue
 2. King Street and Park Center Drive
 3. King Street and Menokin Drive
 4. King Street and Kenwood Avenue
 5. King Street and Janney's Lane
 6. Richmond Highway and Custis Avenue
 7. Patrick Street and Princess Street or Oronoco Street
 8. Washington Street and Princess Street or Oronoco Street
 9. King Street and Dawes Ave
 10. Richmond Highway and Franklin Street
 11. Seminary Road and Hammond MS
- Link the existing traffic signal cabinets to the fiber optic communication cable system using Passive Optical Network (PON) technology. A total of fifty-eight (58) intersections will be connected to the signal system via fiber-optic network. Intersections will be connected to the signal system via existing fiber optic cable or by installing new fiber optic cable. The existing traffic signal cabinets will be interconnected to the fiber optic communication cable along
 - Duke Street between S Quaker Lane and Columbus Street,
 - Duke Street between Ripley Street and S Reynold Street,
 - King Street between Callahan Drive and Chesterfield Street,
 - N Beauregard Street between Braddock Road and Fillmore Street,
 - Eisenhower Avenue between Swamp Fox Road and John Carlyle Street,
 - Van Dorn Street between Eisenhower Avenue and Duke Street, and
 - Seminary Road between Dawes Street and St. Stephans Street.
- Expansion of the TMC video wall include installation of fifteen (15) 55" LCD monitors on the west side and one (1) 98" interactive LCD monitor on the north side of the TMC, and hardware and software needed for the upgrade.
- Bring the feed for the conditions map to a dedicated workstation system in the Traffic Control Center by connecting to IT server. Workstation System shall have the capability to display conditions map on to video wall and any consoles in TMC via KVM switch.

The Contractor will be required to perform the following major tasks under this contract, as shown in the Plans (the list that follows is not meant to be all-inclusive):

- Furnish and install a new Gigabit Ethernet-based fiber-optic communications system for the CCTV system comprised of fiber-optic cable, fiber-optic drop cables, and fiber-optic splice centers (i.e., interconnect centers, etc.), Ethernet switches and related electronics;
- Furnish and install underground conduit/duct, junction boxes, and splice enclosures;
- Furnish and install fiber Ethernet edge switches;
- Furnish and install passive fiber-optic network terminals;
- Furnish and install CCTV camera assemblies;
- Install new electrical services and associated grounding;
- Fully integrate all new components, into fully functioning Ethernet-based, active and passive fiber-optic communications networks;
- Fully integrate all new CCTV cameras into existing fully functioning video monitoring system;
- Furnish and install new fiber optic cable and new conduit;
- Link existing traffic signal cabinets to the fiber optic communication cable system using PON technology;
- Furnish and install termination cabinets;
- Furnish and install Conditions map workstation system;
- Furnish and install Video Wall system comprising of fifteen (15) 55” monitors and one (1) 98” monitor and related hardware and software

Coordinate and ensure seamless integration with any construction projects within the boundaries of this project.

(B) Specifications and Special Provisions

The Contractor shall conform to these Project Special Provisions and the Virginia Department of Transportation (VDOT) *Road and Bridge Specifications*, dated 2020, hereinafter referred to as the “*Road and Bridge Specifications*” and all applicable revisions (see <http://www.virginiadot.org/business/const/spec-default.asp>) the VDOT *Road and Bridge Standards*, dated 2020, hereinafter referred to the “*Road and Bridge Standards*” (see https://www.virginiadot.org/business/locdes/2016_road_and_bridge_standards.asp), and all revisions and supplements listed in Section 1.2 of these Project Special Provisions. The Contractor shall conform to the *Virginia Work Area Protection Manual* (VWAPM) (see https://www.virginiadot.org/business/resources/traffic_engineering/2011_WAPM_REV_2.pdf) dated 2019. Conform to the latest edition of the FHWA *Manual of Uniform Traffic Control Devices* (MUTCD).

Within these Project Special Provisions, the “Department” refers to the Virginia Department of Transportation, and the “City” refers to the City of Alexandria Transportation and Environmental Services Division.

Conform to:

- City of Alexandria, Virginia Information Technology Services - Information Technology Acquisition Protocol, February 2011,
- National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP) (where indicated in these Special Provisions), and

- Americans with Disabilities Act (ADA).

(C) Coordination of Plans, Specifications, and Special Provisions

The *Road and Bridge Specifications*, the *Road and Bridge Standards*, the Plans and these Project Special Provisions are essential parts of the contract, and a requirement occurring in one is as binding as though occurring in all. They are complementary and provide and describe the complete contract. In case of a discrepancy or conflict, the following will apply in ascending order:

- Calculated dimensions shall govern over scaled dimensions;
- Plans shall govern over *Road and Bridge Specifications* and *Road and Bridge Standards*;
- Project Special Provisions shall govern over *Road and Bridge Specifications* and *Road and Bridge Standards*.

In the event of a contradiction within the Project Special Provisions as to the measurement and payment of any pay item, the text of the respective Measurement and Payment subsection for the pay item in question shall govern.

The contractor shall not take advantage of any apparent error or omission in the contract. In the event such errors or omissions are discovered, the Engineer will make such corrections and interpretations as may be determined necessary for the fulfillment of the intent of the contract.

1.2. MATERIALS

(A) Qualified Products

Furnish new equipment, materials, and hardware unless otherwise required. Inscribe manufacturer's name, model number, serial number, and any additional information needed for proper identification on each piece of equipment housed in a case or housing.

The *VDOT Pre-Approved Traffic Control Device Listing* (PATCDL) is available on the Virginia Department of Transportation's website. Certain signal and communications equipment, material, and hardware shall be pre-approved on the PATCDL by the date of installation. Equipment, material, and hardware not pre-approved when required will not be allowed for use on the project. Consult the PATCDL website, <http://www.virginiadot.org/business/trafficeng-productlists.asp> to obtain pre-approval procedures. The City reserves the right to accept certain items that are not on the PATCDL list.

(B) Submittal Requirements

The Contractor shall provide written certification to the City that all Contractor-furnished material is in accordance with the contract. When requested by the City, provide additional certifications from independent testing laboratories and sufficient data to verify item meets applicable specifications. The Contractor shall ensure additional certification states the testing laboratory is independent of the material manufacturer and neither the laboratory nor the manufacturer has a vested interest in the other.

Identify all proprietary parts in Contractor-furnished material. The City reserves the right to reject material that uses proprietary components not commercially available.

For Contractor-furnished material listed on the PATCDL, furnish submittals in the format defined by the PATCDL.

For Contractor-furnished material not on the PATCDL, furnish three copies of the equipment list including three copies of catalog cuts. Identify proposed material on catalog cuts by a reproducible means (highlighter pen does not transfer to copies). Ensure material lists contain material description, brand name, manufacturer's address and telephone number, stock number, size, identifying trademark or symbol, and other appropriate ratings.

Do not fabricate or order material until receipt of the Engineer's approval.

See further requirements for submittal in "Submittal Data" section.

(C) Observation Period

Prior to final acceptance, all Contractor-furnished equipment and software shall successfully complete a 60-day Observation Period.

The 60-day Observation Period is considered to be part of the work included in the total contract time and must be completed prior to final acceptance of the project.

Final acceptance will occur following the successful completion of the 60-day Observation Period and after all documentation requirements have been fully satisfied.

Refer to the "Testing and Acceptance" section of these Project Special Provisions for additional requirements.

(D) Warranties

Unless otherwise required herein, provide manufacturer's warranties on Contractor-furnished equipment for material and workmanship that are customarily issued by the equipment manufacturer or that are at least one (1) year in length, whichever is greater, from the date of final acceptance of the project by the City. Include unconditional coverage for all parts and labor necessary or incidental to repair of defective equipment or workmanship and malfunctions that arise during warranty period.

Ensure all Contractor-furnished equipment, including pieces and components of equipment, hardware, firmware, software, middleware, internal components, and subroutines which perform any date or time data recognition function, calculation, or sequencing will support a four digit year format for a period of at least 50 years and will support user-definable parameters for setting the start and end dates for daylight savings time.

Upon receipt of the City's written final acceptance of project, transfer manufacturer's warranties with proper validation by the manufacturer to the City.

(E) Firmware Licensing and Upgrades

The contractor shall provide the City with a license to duplicate all programmable devices in equipment for maintenance and software upgrades. Provide binary or hexadecimal format files for each device that may be programmed by the City. Ensure files are provided on PC compatible compact disks or other approved media.

The contractor shall ensure software/firmware performance upgrades that occur during the contract period up through final acceptance of the project are furnished to the City and installed/integrated at no additional cost.

The contractor shall make software/firmware upgrades that are developed to correct operating characteristics available to the City at no additional cost until the warranty period expires.

The contractor shall provide licensed copies of all software/firmware to the City. The City shall have the right to install all software/firmware for maintenance and support on all hardware provided

under this contract. This shall include but not be limited to all servers for the CCTV System, LAN System, and network. Provide software/firmware for maintenance and support of workstations, system support software, utility software, and CCTV systems and controllers, and all other programmable devices.

(F) Wire and Cable

The contractor shall furnish wire and cable on reels. When requested by the City, furnish samples of wire and cable to the City at no additional cost.

(G) Painting

Where painting is required, apply paint at the factory. No field painting will be allowed except when paint has been scratched or marred or for such items as weatherheads and CCTV camera mounting plates field-installed on existing metal poles. In such cases, apply two field coats of the same color and grade enamel as the original paint to the scratched or marred portions and to the weatherhead and mounting plate. For the aforementioned unfinished components that require field painting, prepare the surface to receive the paint in accordance with the coating manufacturer's instructions, including application of primer. Make every effort to match color/finish of CCTV mounting hardware to the color of the mast arm.

1.3. PROCEDURES

(A) General

The contractor shall locate all existing conduit, cable runs, and underground utilities before beginning drilling, digging, and trenching operations. Notify "Virginia 811" and abide by rules and restrictions thereof.

Traffic Network Engineer Mark Skinger (703) 746-4148 is the initial point of contact for all references to the City of Alexandria Engineer or Engineer in the Project Plans and/or the Project Special Provisions. Any deviation from the Project Plans and/or Special Provisions must be approved by the Engineer. Project Inspectors do not have authority to approve deviations without the concurrence of the Engineer.

Call Traffic Network Engineer Mark Skinger (703) 746-4148 at least 72 hours before beginning any construction work. Ensure that an IMSA certified, Level II signal technician is standing by to provide emergency maintenance services whenever work is being performed in the proximity of traffic signal controller cabinets and traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

The contractor shall immediately cease work and notify the Engineer and affected owners if damage to existing utilities, cables, or equipment occurs. Make all required repairs and replacements at no additional cost to the City.

The contractor shall avoid trimming (i.e., pruning) trees wherever possible. Removal of trees is strictly prohibited.

The contractor shall maintain access to sidewalks, pushbuttons, ADA ramps, benches, bus stops, etc. during construction unless unavoidable. Conduct any required sidewalk closures in accordance with the MUCTD and the VWAPM.

The contractor shall deliver “Furnish Only” equipment to the City Traffic Engineering Office located at 2900-B Business Center Drive in Alexandria. Furnish the Engineer one (1) full working days’ notice before delivering such equipment.

(B) Work within Historic Districts

Several signalized intersections, some proposed CCTV camera sites and several fiber-optic communications cable routes lie within or adjacent to historic districts. The City has coordinated with the agencies that have jurisdiction over these historic districts and has received the permits and certificates for the work called for in the Plans in these historic districts.

The contractor shall not deviate from the work called for in the Plans within a historic district without the prior approval of the Engineer and the agency/agencies that have jurisdiction over the historic district. Where construction work must deviate from the Plans, notify the Engineer in 15 days in advance so that the City can request/apply for the appropriate approvals for such changes prior to the Contractor performing work at that location.

The Contractor shall conduct a quality level “A” (QL “A”) non-intrusive dig (vacuum excavation) where the proposed conduit crosses any water, gas, telecommunications, electrical power, fiber-optic cable, or traffic communications cable. The Contractor may hand dig test holes if he determines that method is less destructive than a vacuum excavation. The Contractor shall provide a report for each test hole that identifies the type of utility, the horizontal location, and the depth of the utility.

As a result of conduit installation, the Contractor shall replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish, and general appearance of the surrounding pavement. For unpaved areas, the Contractor shall backfill excavations with removed material, tamp the backfilled material, and rake smooth the top 1½ inches. The Contractor shall finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. The Contractor shall seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

The Contractor shall avoid damaging or removing sidewalks and curbs within designated historic districts whenever possible. The Contractor shall not damage, disturb, or remove any existing granite curbs. Where granite curbs conflict with the installation of underground conduit and cable, the Contractor shall bore (drill) conduit underneath granite curb. The Contractor shall not bore through granite curbs. The Contractor shall replace any granite curb damaged due to construction of this project at no cost to the City.

Where removal and replacement of concrete sidewalk and concrete curb is unavoidable, the Contractor shall replace them with concrete materials that match the finish, appearance and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. Finishes may include but are not limited to water-washed, broom and trowel. The dimensions and the profile (i.e., shape) of the new curbing shall match that of the adjacent existing curbing.

Where removal and replacement of sidewalk constructed of materials other than concrete is unavoidable, the Contractor shall replace the sidewalk with in-kind materials that match the finish, appearance and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. If the sidewalk is constructed of materials such as brick, stone or pavers, the Contractor shall carefully remove and subsequently reinstall the bricks, stones or pavers using methods approved by the Engineer. The Contractor shall take photographs and make sketches to record the pattern of the existing materials prior to removal. The Contractor shall replace any bricks,

stones or pavers damaged due to construction on this project with approved in-kind, matching materials at no cost to the City.

The Contractor shall complete all repairs with in-kind materials to all sidewalks removed for construction and reopen the repaired and restored sidewalk to pedestrian traffic within five consecutive calendar days following initial removal. If the Contractor fails to repair and reopen a sidewalk in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the sidewalk will be deducted from payment due the Contractor, plus \$500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

The Contractor shall not trim, remove or damage tree limbs within historic districts.

(C) Work within the Central Business District (CBD)

The central business district (CBD) in downtown Alexandria may experience large volumes of vehicular and pedestrian traffic generated by special events. The CBD is defined as the area in downtown Alexandria bounded by the METRO rail tracks and Mill Road on the west, Slater Lane on the north, the Potomac River on the east and I-495 on the south inclusive. The CBD is occasionally the site of festivals and parades and other cultural events and celebrations; coordination/scheduling of work to avoid such events is the responsibility of the Contractor. See the Maintenance of Traffic section of the Plans for additional requirements.

The Contractor shall not perform any work within the CBD without prior approval of the City. Submit to the City for review and approval two weeks in advance a schedule for proposed work that will require narrowing or closing a lane, road, sidewalk or pedestrian crossing within this area.

The Contractor shall conduct a quality level "A" (QL "A") non-intrusive dig (vacuum excavation) where the proposed conduit crosses any water, gas, telecommunications, electrical power, fiber-optic cable, or traffic communications cable. The Contractor shall provide a report for each test hole that identifies the type of utility, the horizontal location, and the depth of the utility.

As a result of conduit installation, the Contractor shall replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish, and general appearance of the surrounding pavement. For unpaved areas, the Contractor shall backfill excavations with removed material, tamp the backfilled material, and rake smooth the top 1½ inches. The Contractor shall finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. The Contractor shall seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

The Contractor shall avoid damaging or removing sidewalks and curbs within designated historic districts whenever possible. The Contractor shall not damage, disturb, or remove any existing granite curbs. Where granite curbs conflict with the installation of underground conduit and cable, the Contractor shall bore (drill) conduit underneath granite curb. The Contractor shall not bore through granite curbs. The Contractor shall replace any granite curb damaged due to construction of this project at no cost to the City.

Where removal and replacement of concrete sidewalk and concrete curb is unavoidable, the Contractor shall replace them with concrete materials that match the finish, appearance, and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. Finishes

may include but are not limited to water-washed, broom and trowel. The dimensions and the profile (i.e., shape) of the new curbing shall match that of the adjacent existing curbing.

Where removal and replacement of sidewalk constructed of materials other than concrete is unavoidable, the Contractor shall replace the sidewalk with in-kind materials that match the finish, appearance, and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. If the sidewalk is constructed of materials such as brick, stone, or pavers, the Contractor shall carefully remove and subsequently reinstall the bricks, stones, or pavers using the same base material and methods approved by the Engineer. The Contractor shall take photographs and make sketches to record the pattern of the existing materials prior to removal. The Contractor shall replace any bricks, stones, or pavers damaged due to construction on this project with approved in-kind, matching materials at no cost to the City.

The Contractor shall complete all repairs with in-kind materials to all sidewalks removed for construction and reopen the repaired and restored sidewalk to pedestrian traffic within five consecutive calendar days following initial removal. If the Contractor fails to repair and reopen a sidewalk in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the sidewalk shall be deducted from payment due the Contractor, plus \$500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

The Contractor shall not trim, remove or damage tree limbs within historic districts.

(D) Work within Areas outside the Central Business District (CBD)

Non-CBD areas are areas outside downtown Alexandria and historic districts. The Contractor shall conduct a quality level "A" (QL "A") non-intrusive dig (vacuum excavation) where the proposed conduit crosses any water, gas, telecommunications, electrical power, fiber-optic cable, or traffic communications cable. The Contractor shall provide a report for each test hole that identifies the type of utility, the horizontal location, and the depth of the utility.

As a result of conduit installation, the Contractor shall replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish, and general appearance of the surrounding pavement. For unpaved areas, the Contractor shall backfill excavations with removed material, tamp the backfilled material, and rake smooth the top 1½ inches. The Contractor shall finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. The Contractor shall seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

The Contractor shall avoid damaging or removing sidewalks and curbs within designated historic districts whenever possible. The Contractor shall not damage, disturb, or remove any existing granite curbs. Where granite curbs conflict with the installation of underground conduit and cable, the Contractor shall bore (drill) conduit underneath granite curb. The Contractor shall not bore through granite curbs. The Contractor shall replace any granite curb damaged due to construction of this project at no cost to the City.

Where removal and replacement of concrete sidewalk and concrete curb is unavoidable, the Contractor shall replace them with concrete materials that match the finish, appearance, and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. Finishes may include but are not limited to water-washed, broom and trowel. The dimensions and the profile (i.e., shape) of the new curbing shall match that of the adjacent existing curbing.

Where removal and replacement of sidewalk constructed of materials other than concrete is unavoidable, the Contractor shall replace the sidewalk with in-kind materials that match the finish, appearance, and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. If the sidewalk is constructed of materials such as brick, stone, or pavers, the Contractor shall carefully remove and subsequently reinstall the bricks, stones, or pavers using methods approved by the Engineer. The Contractor shall take photographs and make sketches to record the pattern of the existing materials prior to removal. The Contractor shall replace any bricks, stones, or pavers damaged due to construction on this project with approved in-kind, matching materials at no cost to the City.

The Contractor shall complete all repairs with in-kind materials to all sidewalks removed for construction and reopen the repaired and restored sidewalk to pedestrian traffic within five consecutive calendar days following initial removal. If the Contractor fails to repair and reopen a sidewalk in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the sidewalk shall be deducted from payment due the Contractor, plus \$500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

The Contractor shall not trim, remove or damage tree limbs within historic districts.

(E) Regulations and Codes

The Contractor shall furnish material and workmanship conforming to the *National Electric Code* (NEC), *National Electric Safety Code* (NESC), Underwriters Laboratories (UL), or other listing agencies approved by the Virginia Department of Insurance, and all local safety codes in effect on the date of advertisement. Comply with *Code of Virginia* regarding the licensing of electrical contractors). Comply with the Plans, all previously referenced specifications, and all applicable local ordinances and regulations before and during all stages of the electrical work.

When required by the local ordinances and governmental agencies, upon completion of the work, have all systems inspected and approved in writing by the authorized governmental electrical inspector for the area. Furnish written certification of the authorized inspector's approval to the Engineer. Inspection by the authorized governmental electrical inspector must neither eliminate nor take the place of the inspections by the Engineer. Upon the Engineer's receipt of written certification and the Contractor's written request for a final inspection of the installations, the Engineer will perform a final inspection.

Where required, all work shall conform to ITE, AASHTO, and ASTM standards in effect on the date of advertisement.

The Contractor shall notify the Engineer and affected local utility companies, seven business days before operational shutdowns to coordinate connection or disconnection to an existing utility or system, unless otherwise instructed herein.

The Contractor shall install meter bases and service disconnects as required by the NESC, NEC, local utility companies, and local ordinances. Standoffs shall be installed only when required and approved by the local utility companies. Where a standoff shall be used, obtain the local utility company's approval prior to installing the standoff.

(F) Utility Services

The Contractor shall coordinate all work to ensure electrical power of proper voltage, phase, frequency, and ampacity is available to complete the work. Use electrical service cables with THWN insulation.

When electrical, telephone, and telecommunication service is not furnished by the City and is required, the Contractor shall contact the utility company and make application to ensure all work can be completed. The Contractor shall obtain authorization and make application for service in the City's name for City-owned locations.

The City shall be responsible for direct payment of monthly utility company usage charges. The Contractor shall be responsible for all expenses associated with utility installation costs, hookups, etc.

Coordinate all work involving electrical service with the appropriate electric utility company. Coordinate with the utility company to ascertain the feasibility of installing electrical service at each location before performing any work. Obtain all required local permits before beginning work.

(G) Maintenance and Repair of Material

The Contractor shall ensure that an IMSA-certified Level 2 technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

Furnish the Engineer with the name, office telephone number, cellular (mobile) telephone number, and pager number of the supervisory employee who will be responsible for maintenance and repair of equipment during all hours.

The Contractor shall maintain and repair all signal and communications related equipment within the project construction limits until completion of the Observation Period and receipt of written notification of final acceptance of the project. This requirement for maintaining and repairing said equipment shall remain in effect in the event of a natural disaster such as flood, ice storm, tropical storm or hurricane.

The Contractor shall make entries into the maintenance diaries housed inside each traffic signal controller cabinet upon each visit to the controller cabinet. The Contractor shall maintain these diaries through final acceptance of the project.

For all failures, malfunctions, damages to equipment or errors in workmanship affecting signal operation, the Contractor shall begin necessary repairs within one hour of notification. Complete repairs within eight hours of notification. The Contractor shall comply with Section 512 of the Road and Bridge Specifications for maintenance of traffic flow. The inability to contact the supervisory employee or prearranged alternate will not extend repair time requirements.

The Contractor shall remove all contractor-supplied communications related equipment that fails. The Contractor shall purchase, pay for delivery, store (if necessary), replace, and integrate all such equipment. The Contractor shall notify the City if City-furnished equipment is observed to fail or degrade.

Except for damages and malfunctions caused by the Contractor's work activities, the Contractor shall not be held responsible for pre-existing conditions reported to the Engineer before starting traffic signal-related, CCTV camera, or TMC work. The Contractor shall assume responsibility for all maintenance and emergency services necessary once traffic signal-related or CCTV camera work has

begun at the specific intersection, and at the TMC and for all damages and malfunctions caused either directly or indirectly by the Contractor's work activities.

In the event the Contractor fails to perform in accordance with the Plans and Project Special Provisions within the period specified, the City reserves the right to perform maintenance and emergency service necessary to ensure continuous traffic signal operation. Further, all expenses incurred by the City in implementing this option will be deducted from payment due the Contractor, plus \$2,500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

(H) Removal of Existing Equipment and Material

Remove all unnecessary existing City-owned CCTV and communications related equipment and material that will not be used. Return all other City-owned equipment and material between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the City Signal Shop located at 3200 Colvin St. in Alexandria. The City will deduct the cost of City-owned equipment damaged by the Contractor from money due to the Contractor.

(I) Wire and Cable

For installation in a conduit system, lubricate cable and wires before installing in conduit. Use lubricant that will not physically or chemically harm cable jacket, wire insulation, and conduit.

The Contractor shall perform the following:

Terminate all electrical wire and cable inside cabinets at nickel-plated brass, recessed-screw, barrier-type terminal blocks or using gel-filled splice connectors. Category 5e cable shall be terminated with RJ-45 connectors. Electrical wire and cable shall be run continuously without splices.

Splice all fiber-optic cable in splice enclosures within underground junction boxes, or in splice trays in termination cabinets.

Unless specifically allowed, connect no more than two conductors to the same terminal screw.

Maintain color-coding of wires through splices.

Protect ends of wire and cable from water and moisture.

Place permanent labels on all wires and cables to identify clearly each one. Use an indelible black ink marker or approved labeling devices to write on the permanent labels when required.

Install all wire and cable with necessary hardware including, but not limited to shoulder eyebolts, washers, nuts, thimbleyelets, three-bolt clamps, J-hooks, split bolt connectors, grounding clamps, and lashing material.

(J) Electrical Services and Grounding

At CCTV sites where cameras are mounted on existing traffic signal mast-arm poles, the Contractor shall test the new grounding electrode system to ensure a resistance of 20 Ω or less.

The Contractor shall provide grounding electrode system at all new electrical services. In addition to NEC requirements, the Contractor shall test grounding electrode resistance for a maximum of 20 ohms. The Contractor shall furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements. The Contractor shall install ground rods only in junction boxes.

The Contractor shall modify existing electrical services, as necessary, to meet the grounding requirements of the NEC, the *Road and Bridge Specifications*, and the project plans. Where a grounding electrode system is connected to the electrical service in accordance with the NEC, the

Contractor shall test grounding electrode resistance for a maximum of 20 ohms. Grounding electrode resistance test shall be verified or witnessed by the Engineer or the Engineer's designated representative. Furnish and install additional ground rods to grounding electrode system as necessary to meet the *Road and Bridge Specifications* and test requirements.

The Contractor shall follow test equipment's procedures for measuring grounding electrode resistance. When using clamp-type ground resistance meters, readings of less than 1 ohm typically indicate a ground loop. The Contractor shall rework bonding and grounding circuits as necessary to remove ground loop circuits and retest. If a ground loop cannot be identified and removed to allow the proper use of a clamp-type ground resistance meter, the Contractor shall use the three-point test method.

The Contractor shall provide a length of marker tape 6 to 12 inches below finished grade directly over grounding electrodes and conductors.

(K) Electrical Bonding

The Contractor shall connect a number 19-strand copper conductor (Type THW) (6 AWG minimum for bonding of poles) with green insulation to serve as an equipment grounding conductor to metal poles, and other metallic components which are not otherwise bonded, through means approved by the Engineer. The Contractor shall use an exothermic welding process to bond ground wire to ground rod.

(L) City IT Staff Coordination

No work shall be conducted in the City LAN room, or modifications made to City LAN equipment, without City IT (ITS) staff being present. Notify City IT staff at least 7 days prior to such work being scheduled.

1.4. CONSTRUCTION STAGING

The Contractor shall submit a detailed field construction plan (including details of cabinet, pole, and communication infrastructure) and schedule to the City for review and approval at least 15 days prior to the onset of work, and no later than 60 days after Notice to Proceed. Include information such as details of crew size, time of day, sequence of activities, etc. The overall schedule should follow the general construction sequence of utility investigation, conduit installation, junction box installation, fiber installation, field equipment installation, and integration.

The Contractor shall comply with the Sequence of Construction section of the Plans.

1.5. MAINTENANCE OF TRAFFIC

The Contractor shall comply with the latest edition of the *Virginia Work Area Protection Manual*. Maintenance of Traffic shall be paid for at the lump sum price for "Maintenance of Traffic".

Measurement and Payment

Pay Item	Pay Unit
Maintenance of Traffic	Lump Sum

1.6. DOCUMENTATION

(A) General

The Contractor shall provide all as-built documentation. All as-built plans and documentation shall be reviewed and accepted by the Engineer prior to final acceptance of the project. All documentation, except as otherwise specifically approved by the Engineer, shall meet the following requirements:

1. Provide any documentation that exceeds the size of 11" x 17" paper in a reproducible format 22" x 34" in size.
2. No documentation for as-built plans smaller than 8.5" x 11" shall be accepted.
3. Do not fold or crease reproducible drawings.

As a minimum, provide the documentation described in the paragraphs below.

(B) Plan of Record Documentation

The Contractor shall provide as-built drawings that depict any changes of components, measurement, or layout of the Plans. The Contractor shall show all construction changes, with the final location and depth of conduits, wiring external to the cabinet, locations of splice closures, and SMFO cable terminations, etc., in detail in a reproducible format. The Contractor shall submit as-built construction changes as soon as a change is complete. The Contractor shall note and date each change on the drawings. Failure to revise as-built documentation to reflect current work may result in withholding of payments until the as-built documentation is updated.

The submitted as-built documentation may be field-checked by the Engineer at his discretion. If the as-built documentation is found to have an unacceptable number of inaccuracies, the Engineer may withhold payment until the as-built plans are corrected. The Contractor shall include all field installation including the SMFO cable network installed on the drawings.

For underground conduit systems that house communications cable, the Contractor shall furnish the Engineer with a plan of record drawing detailing the locations of the conduit system, including junction boxes and their corresponding GPS coordinates. For directionally-drilled underground conduit systems, the Contractor shall identify the vertical location (i.e., depth) and the offset distance from face of curb if applicable, of the conduits along the run.

The Contractor shall store documentation for CCTV installations in signal cabinets in a manila envelope placed in a weatherproof holder inside the cabinet drawer. If no drawer is present, then store as directed by the Engineer. Store all documentation furnished with the cabinets, including manuals, electrical schematic diagram, and cabinet wiring diagram inside the envelope in the weatherproof holder. The Contractor shall provide two marked-up "redline" copies of the CCTV plan, placing one copy in the weatherproof holder inside the cabinet drawer immediately upon installation of the cabinet and giving the second copy to the Engineer.

For CCTV camera assemblies, the Contractor shall provide two copies of a parts list(s) that includes serial and model numbers of all Contractor-furnished equipment prior to final acceptance. All equipment and appurtenances shall be identified by name, model number, serial number, technical support, and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance.

The City shall provide the Contractor one electronic copy of the Plans for his use in developing the as-built drawings. The Contractor shall modify the original electronic file such that all changes are marked with callout boxes or other method approved by the Engineer. Any other base maps that may be necessary for the Contractor to prepare the as-built drawings in accordance with these Project

Special Provisions shall be the Contractor's responsibility. Use CADD conventions that are consistent with those used on the original plans.

Within 10 days after the Observation Period begins, the Contractor shall furnish one reproducible copy of the draft as-built plans in hard copy format for review. Provide draft hard copy as-built drawings on 11"x 17" bond plan sheets.

Upon receipt of review comments from the Engineer, the Contractor shall correct any errors and make all necessary revisions to the draft as-built plans prior to final acceptance of the project. The Contractor shall submit final as-built plans in electronic and hard copy format. The Contractor shall provide electronic plans in AutoCAD format on CD or DVD. Contact the City to determine the AutoCAD version currently in use.

(C) Manuals

The Contractor shall provide at least five hard copies along with one electronic copy (on CD or DVD) of the following manuals:

- Operator's manuals containing detailed operating instructions for each different type of model of equipment. The Contractor shall ensure that manuals contain instructions for possible modification to equipment. Such equipment includes, but is not limited to cameras, surge protection devices, switches, servers, workstations, KVMs, monitors, central software, etc.
- Maintenance procedures manuals containing detailed preventative and corrective maintenance procedures and troubleshooting procedures for each different type of model of equipment.
- Installation, operations, and training manuals for all Contractor-provided software.

The manuals provided above shall be in addition to manuals provided with and stored inside each control equipment cabinet.

(D) Splice Diagrams

The Contractor shall prepare as-built splice diagrams that depict the communications cable plant as constructed. Depict the splices made at each splice enclosure by identifying spliced fiber and buffer tube. Ensure the splice diagram is in a similar format to those provided with the project plans. Identify all expressed fibers, spare fibers, used fibers and capped fibers.

Original splice diagrams shall be provided in electronic format in AutoCAD format. Designate any changes to these diagrams by using a method approved by the Engineer. Furnish as-built splice diagrams in AutoCAD format on CD or DVD and in hard copy. Contact the City to determine the AutoCAD version currently in use.

2. MOBILIZATION

2.1. DESCRIPTION

This work shall consist of preparatory work and operations, including but not limited to the movement of personnel, equipment, supplies, and incidentals to the project site, for the establishment of offices, buildings, and other facilities necessary for work on the project. The work shall also include the removal and disbandment of those personnel, equipment, supplies, incidentals, or other facilities that were established for the prosecution of work on the project, and for all other work and operations that shall be performed for costs incurred prior to the beginning of work on the various items on the project site. Refer to the Section 513 of the *Road and Bridge Specifications*.

2.2. MEASUREMENT AND PAYMENT

“Mobilization” will be paid for in accordance with VDOT Specification Section 513.02.

Measurement and Payment

Pay Item	Pay Unit
Mobilization	Lump Sum

3. UNDERGROUND CONDUIT

3.1. DESCRIPTION

The Contractor shall furnish and install conduit for underground installation with tracer wire, pull line, miscellaneous fittings, all necessary hardware, marker tape, backfill, graded stone, paving materials, and seeding and mulching. The Contractor shall furnish conduit of the size shown on the plans.

3.2. MATERIALS

Conduit, material, equipment, and hardware furnished under this section shall be pre-approved on the Department's PATCDL.

Exception: The city reserves the right to accept certain items through the Engineering review process outlined in 1.2.B

Refer to the Section 238 of the *Road and Bridge Specifications*:

(A) Conduit Plugs, Sealing Putty, Pull Line, and Tracer Wire

The Contractor shall furnish duct plugs that provide a watertight barrier when installed in conduit and sized in accordance with conduit. The Contractor shall ensure duct plug provides a means to secure a pull line (also known as a pull tape or mule tape) to the end of the plug. Provide removable and reusable duct plugs.

The Contractor shall furnish mechanical sealing devices that provide a watertight barrier between conduit and cables in conduit. The Contractor shall furnish mechanical sealing devices sized in accordance with conduit and with appropriately sized holes to accommodate and seal cables. Provide removable and re-usable mechanical sealing devices.

- Furnish moldable sealing putty that shall have the following characteristics:
- Contains no asbestos;
- Designed for use with electrical and telecommunications cables house in conduits
- Adheres to various conduit materials, including PVC, high density polyethylene (PE) and galvanized steel;
- Forms a moisture barrier to prevent the entry of water and/or debris into the conduit;
- Requires no mixing or additives (single-component) and requires no volatile solvents; and
- Can be applied and readily removed by hand and remains pliable and non-hardening.

The Contractor shall furnish 1/2", pre-lubricated, woven polyester tape, pull line (also known as a pull tape or mule tape) with minimum rated tensile strength of 2,500 lb for proposed and existing conduit. Pull tape shall have preprinted footage markings for the purposes of measuring established conduit runs

The Contractor shall provide polyethylene (PE) insulated number #12 AWG, copper clad steel wire to serve as tracer wire in proposed and existing conduit if not present. Contractor may supply copper-clad steel tracer wire specifically manufactured as tracer wire for underground applications with Engineer approval of submittal.

Furnish non-detectable underground marker tape with the wording "CAUTION: BURIED FIBER OPTIC LINE BELOW" or similar standard message at least 12 inches above the installed conduits in all trenches containing one or more conduits that shall house fiber-optic communications cable.

(B) Mechanical Couplings for PE Conduit

– Mechanical couplings shall only be allowed for conduit installed by trenching. Mechanical couplings may be allowed for transitioning directional drilled conduit to conduit installed by trenching. Mechanical couplings shall not be allowed for conduit installed by directional drilling unless prior approval is received by the Engineer. The Contractor shall provide mechanical couplings that are both watertight and airtight for joining two segments of high-density polyethylene (PE) conduit of like diameter. Provide couplings with threads or couplings that provide a mechanical means of gripping and locking into the coupled conduit ends. Provide couplings impervious to corrosion. Provide couplings designed to accommodate pneumatic methods of cable installation. Provide couplings manufacturer-approved and listed for direct burial. Couplings that rely on glue/cement shall not be accepted for use on PE conduit ends.

(C) Test Holes

The Contractor shall conduct a quality level “A” (QL “A”) non-intrusive dig (vacuum excavation) where the proposed conduit (whether trenched or directionally drilled) crosses any water, gas, telecommunications, electrical power, fiber-optic cable, traffic communications/signal cable, or sanitary/storm sewer mains and laterals. The Contractor shall provide a report for each test hole that identifies the type of utility, the horizontal location, and the depth of the utility. Test holes are considered incidental to installation of conduit by means of trenching (ground), trenching (pavement), or directional drilling.

3.3. PROCEDURES

(A) General

Except where the Plans call for a specific installation method or where the Engineer directs otherwise, underground conduit shall be installed by either trenching (ground), trenching (pavement), directional drilling or plowing at the option of the Contractor.

Refer to Section 1 of these Project Special Provisions for additional requirements concerning work within and adjacent to historic districts.

The Contractor shall ensure conduit is free of water and debris before pulling cables.

Where cable is not immediately installed or where conduit is for future use (spare), seal the ends of the conduit with a duct plug immediately upon installation of the conduit. Secure a pull line (also known as a pull tape or mule tape) to the duct plug in such a manner that it shall not interfere with installation of the duct plug and provides a watertight seal.

Extend ends of conduit 2 to 4 inches above concrete surfaces and 4 inches above crushed stone bases. For metallic conduit, install metallic bushings and bond conduits.

All conduits installed in a common trench or bore shall be the same size and all conduits in a continuous longitudinal run shall be the same size. Do not intermix different size conduits in the same run.

Install junction boxes in underground conduit runs as shown on the Plans. Do not exceed 1500 feet between junction boxes in any underground conduit route that conveys communications cable without the prior approval the Engineer.

(1) Conduit Entering Junction Boxes

The Contractor shall terminate conduits installed for communications cables in junction boxes as shown on the Plans. Do not install other conduits in these junction boxes unless otherwise specified. Conduits containing fiber optic cable shall not enter a pullbox at an angle greater than 45 degrees.

For all conduits entering junction boxes, the Contractor shall seal spare conduits with approved duct plugs. The Contractor shall seal conduits containing fiber-optic communications cable with mechanical sealing devices or moldable sealing putty. The Contractor shall seal conduits containing Hybrid CCTV cable or fiber-optic drop cable with moldable sealing putty.

(2) Tracer Wire

The Contractor shall install tracer wire in all conduits containing fiber-optic cable, unless otherwise indicated on the Plans or the Engineer directs otherwise. The Contractor shall pull tracer wire simultaneously in a continuous length with the fiber-optic cable. Where multiple pulls of fiber-optic cable are required and conduit is placed in the same trench, only one tracer wire is required. Where multiple pulls of fiber-optic cable are required and conduits may separate into individual trenches, the Contractor shall install a tracer wire in each conduit run. The Contractor shall splice tracer wire only in junction boxes using waterproof butt splice connectors. The Contractor shall Coil and store 3 feet of spare tracer wire in junction boxes and label all tracer wires entering an equipment cabinet. For a given tracer wire run between two controller cabinets, the Contractor shall bond the tracer wire to the equipment ground inside the controller cabinet at one end of run only; do not bond both ends of the tracer wire in a continuous run to cabinet grounds at each end of the run. Establish a consistent convention for which end the tracer wire shall be bonded along a given roadway or corridor. For example, bond the end of the tracer wire closest to (in the direction of) the Alexandria TMC.

(3) Pull Line

If not present in the conduit, the Contractor shall install a pull line (also known as a pull tape or mule tape) in all existing and proposed conduits containing fiber-optic cables as indicated on the Plans. The Contractor shall install a pull line simultaneously in a continuous length with the fiber-optic cable and tracer wire. The Contractor shall store 3 feet of pull line (for each pull line) in junction boxes.

(4) Test Hole

The Contractor shall locate (accurate horizontal and vertical position) all water, gas, telecommunications, electrical power, fiber-optic cable, traffic communications/signal cable utilities, or sanitary/storm sewer mains and laterals that this Project's proposed conduit (whether trenched or directionally drilled) will cross. The Contractor shall provide all equipment, personnel, and supplies required to perform test hole locating. The Contractor shall obtain all necessary permits from the City to work in existing streets, roads, and rights-of-way. The Contractor shall electronically sweep crossings and perform necessary procedures to assure that the test hole is excavated in the correct location and on the correct underground utility. The Contractor shall excavate minimum surface area of soil, concrete, asphalt, bricks or pavers to expose the utility to be measured in such a manner that insures the safety of excavation and the integrity of the utility to be measured. In performing such excavations, the Contractor shall comply with all applicable utility damage prevention laws and coordinate with utility inspectors, as required, and will be responsible for any damage to the utility during excavation of same. The Contractor shall investigate, measure and record horizontal and vertical location of the top and bottom of the utility, the utility structure material (when reasonably ascertainable), type of utility, and utility owner. The Contractor shall repair and restore surface areas

disrupted by trenching (ground), trenching (pavement), or directional drilling as directed in “Ground Surface Restoration” below. Test holes are considered incidental to installation of conduit by means of trenching (ground), trenching (pavement), or directional drilling.

(5) Ground Surface Restoration

Upon completion of conduit installation and backfilling of all trenches and other excavations, the Contractor shall restore the disturbed ground to its original condition as determined and approved by the Engineer. For paved areas, the Contractor shall replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish, and general appearance of the surrounding pavement. Where removal and replacement of concrete sidewalk and is unavoidable, replace with concrete materials that match the finish, appearance and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. For unpaved areas, the Contractor shall backfill excavations with removed material, tamp the backfilled material, and rake smooth the top 1½ inches. The Contractor shall finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. The Contractor shall seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

The Contractor shall restore pavement or sidewalks as per the City’s Design and Construction Standards dated July 1989.

The Contractor shall complete repairs to and restoration of all ground (paved and unpaved) disturbed by construction within five consecutive calendar days following initial removal. If the Contractor fails to repair and restore the ground in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs. All expenses incurred by the City in making the repairs and restoring the ground shall be deducted from payment due the Contractor, plus \$500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

(6) Plan of Record Drawings

Upon completion of the conduit system for communications, the Contractor shall furnish the Engineer with a plan of record drawing detailing both the horizontal and vertical (i.e. depth) locations of the conduit system.

(B) Trenching

(1) General

The Contractor shall install PE, for all underground runs as specified in the Plans unless otherwise shown on plans. The City reserves the right to change the conduit routing from that depicted in the Plans. Clean existing underground conduit to be incorporated into a new system. Bond all metallic conduits.

If more than one conduit is required between the same points, the Contractor shall install conduit in one common trench.

The Contractor shall install non-detectable marker tape longitudinally in the trench 6 to 12 inches below the unpaved ground surface or below the underside of the paved surface.

Install longitudinal runs of conduit a minimum of 1 foot from back of curb or 6 feet from edge of pavement in the absence of curb.

Upon completion, the Contractor shall restore surface to like-original condition within seven calendar days of occurrence of damage. Remove all rock and debris from backfill material. Remove excess material from site and compact area. Backfill with 21A and compact to 95% of original density.

Backfill trench in accordance with Section 302.03 of the *Road and Bridge Specifications*.

After installation of conduits and upon completion of tamping and backfilling, the Contractor shall perform a mandrel test on each conduit to ensure no conduit has been damaged (this is also referred to as “proofing” the conduit). The Contractor shall furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit. The Contractor shall ensure pull line (also known as a pull tape or mule tape) is re-installed.

The Contractor shall use high-density PE or Schedule 80 PVC conduit in trenched areas unless otherwise specified in the Plans.

(2) Trenching (Ground)

The Contractor shall install conduit in unpaved areas. Rake smooth the top 1-1/2 inches and seed with same type of grass as surrounding area. Restore damaged grassed areas. The Contractor shall seed and mulch, using methods and material approved by the Engineer, within five consecutive calendar days following initial damage to grassed areas, unless the Engineer approves otherwise due to weather and soil conditions. If the Contractor fails to repair the grassed areas in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs. All expenses incurred by the City in making the repairs and restoring the grassed area will be deducted from payment due the Contractor, plus \$500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

The Contractor shall adapt operations to variations in weather of soil conditions as necessary for the successful establishment and growth of the grasses. When the Engineer determines that weather and soil conditions are unfavorable, including but not limited to extremely wet or frozen soil, the Contractor shall not distribute any limestone or fertilizer and shall not sow any seed. During seasons of the year when temperatures are not conducive to germination and growth of the type of grass seed to be planted, the Contractor shall seed and mulch the disturbed areas with temporary seeding that will germinate and grow under the prevailing temperatures until such time that permanent seeding can be established, as approved and directed by the Engineer.

As directed by the Engineer, the Contractor shall apply additional seed or completely reseed areas which have been previously seeded and mulched but which have been damaged, have failed to successfully establish a stand of vegetation or have an unsatisfactory cover of vegetation. The Contractor shall perform supplemental and repair seeding promptly at all locations and times as directed by the Engineer.

(3) Trenching (Pavement)

On asphalt surfaces, the Contractor shall neatly cut and replace the width of trench with like material. After installing the conduit, the Contractor shall backfill the trench and compact with excavated soil utilizing six to eight inch horizontal lifts. Compaction shall be at least ninety percent of the theoretical maximum density as defined in Section 101.02 of the Specifications. The Contractor shall ensure that the tamping of soil does not damage the conduit. A mechanical tamping device shall be used to compact the backfill and soil layer by layer around the perimeter of the junction box. Ensure that replacement asphalt thickness is as deep, or deeper, than existing asphalt. The Contractor shall comply with Article 512 of the *Road and Bridge Specifications*.

On concrete surfaces, the Contractor shall replace the entire joint of concrete and match the original concrete as to color and finish unless otherwise specified. On all other surfaces, the Contractor shall neatly cut and replace the width of trench with like material. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. Place graded stone material to maintain temporarily pedestrian traffic where repairs cannot be performed immediately. The Contractor shall comply with Article 512 of the *Road and Bridge Specifications*.

The Contractor shall install a temporary patch before the end of each day's work. The patch must be a minimum of 2 inches thick with a minimum compaction of 90%. The surface should be flushed with adjacent pavement to give smooth ride to traffic and must be maintained in good condition until replaced by permanent patch.

The Contractor shall complete repairs to all paved areas removed for construction within five consecutive calendar days following initial removal. If the Contractor fails to repair the paved area in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the paved area will be deducted from payment due the Contractor, plus \$500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

The Contractor shall finish paved areas with materials matching damaged areas. For conduit installed under roadways, cut neatly and replace the width of paved area damaged by trenching. For conduit installed under sidewalks and walkways, the Contractor shall remove entire section of slab from joint to joint and replace. Place graded stone material to maintain traffic temporarily where repairs cannot be performed immediately. Comply with Article 512 of the *Road and Bridge Specifications*.

(C) Directional Drilling

(1) Pre-Approvals and Minimum Depth Requirements

The Contractor shall obtain approval before beginning drilling operations.

At all points where PE conduit will traverse under roadways, driveways, sidewalks, or Controlled Access Areas including entrance/exit ramps, maintain a minimum depth of 4 feet or 8 times the back reamer's diameter, whichever is deeper. For an installation that runs parallel to a controlled access area or entrance/exit ramps maintain a minimum depth of 30 inches below finished grade. Maintain a minimum clearance of 30 inches below finished grade when crossing ditch lines. For the following structures, the minimum clearance requirements are:

Man-made Structure	Minimum Clearance Requirement
Bridge foundation	5' horizontal & 4' vertical (clearances greater than minimum horizontal should continue to use the 4V:5H ratio, i.e., 10' horizontal should be no deeper than 8')
Drainage pipes 60" or less	1' above or below [while maintaining a minimum depth of 30" below grade]
Drainage pipes greater than 60"	1' above or 4" below [while maintaining a minimum depth of 30" below grade]
Box Culverts	1' above or 4' below [while maintaining a minimum depth of 30" below grade]
Slope protection	2' below
Slope protection foundation footing	5' below

The Contractor shall guarantee the drill rig operator and digital walkover locating system operator are factory-trained to operate the make and model of equipment provided and have a minimum of one-year experience operating the make and model of drill rig. The Contractor shall submit documentation of the operators' training and experience for review at least two weeks before start of directional drilling operations.

The Contractor shall provide a means of collecting and containing drilling fluid/slurry that returns to the surface such as a slurry pit. The Contractor shall provide measures to prevent drilling fluids from entering drainage ditches and storm sewer systems. The Contractor shall prevent drilling fluid/slurry from accumulating on or flowing onto pedestrian walkways, driveways, and streets. Disposal on public right-of-way is prohibited. The Contractor shall immediately remove all drilling fluids/slurry that are accidentally spilled.

(2) Directional Drill Operations

The Contractor shall provide grounding for the drill rig in accordance with the manufacturer's recommendations. Place excavated material near the top of the working pit and dispose of properly. Pits and trenches used to facilitate drilling operations shall be backfilled immediately after drilling is completed.

At all times, the Contractor shall have alternate drill heads available in case the soil conditions do not match expected conditions.

The Contractor shall use drill head suitable for type of material being drilled and sized no more than 2 inches larger than the outer diameter of the conduit. The Contractor shall direct drill to obtain proper depth and desired destination. Pressure grout with an approved bentonite/polymer slurry mixture shall be used to fill all voids. The Contractor shall not jet alone or wet bore with water.

During drilling operation, the Contractor shall locate drill head every 10 feet along drill path and before traversing underground utilities or structures. The Contractor shall use digital walkover locating system to track drill head during directional drilling operation. The Contractor shall ensure locating system is capable of determining pitch, roll, heading, depth, and horizontal position of the drill head at any point.

Once the drill head has reached the final location, the Contractor shall remove the head, and install a back reamer of appropriate size (no more than 2 inches larger than outer diameter of conduits) to simultaneously facilitate back reaming of drill hole and installation of conduit. The Contractor shall use a back reamer that is sized larger than actual conduits to ensure conduits are not adversely subjected to deviations caused by the original drill operation and are as straight as practical in their final position.

The intent of these Project Special Provisions is to limit the diameter of the actual drill shaft/hole so that it is no more than 2 inches larger than the conduit outer diameter. This enlarged diameter may be accomplished either during the original bore or during the back reaming/conduit installation process.

Once installation of conduit has started, the Contractor shall continue installation without interruption to prevent the conduit from becoming firmly set. The Contractor shall apply bentonite/polymer slurry mixture during conduit installation.

Upon completion of conduit installation, the Contractor shall perform a mandrel test on conduit system to ensure conduit has not been damaged (this is also referred to as “proofing” the conduit). The Contractor shall furnish non-metallic mandrel with a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, the Contractor shall replace the entire length of conduit and ensure that pull line (also known as a pull tape or mule tape) is re-installed.

(3) Drilling Fluids

The Contractor shall use lubrication for subsequent removal of material and immediate installation of the conduit. The use of water and other fluids in connection with directional drilling operations will be permitted only to the extent necessary to lubricate cuttings. Do not jet alone or wet bore with water. The Contractor shall use drilling fluid/slurry consisting of at least 10 percent high-grade bentonite/polymer slurry to consolidate excavated material and seal drill hole walls.

The Contractor shall transport waste drilling fluid/slurry from site and dispose of in a method that complies with local, state and federal laws and regulations. Disposal on public right-of-ways or within public drainage ditches/facilities is prohibited.

(D) Microtrenching and Microduct Installation

Furnish and Install 18/14mm HDPE Microduct Under Existing Pavement – Micro-Trenching.
Furnish and Install 18/14mm HDPE Microduct in Unpaved Right-of-Way – Micro-Trenching

(1) Description

This work consists of cutting into existing pavement or unpaved right-of-way to create a trench with a maximum width of 1.5-inches and minimum depth of 7inches and placed in the sub-base below the roadway base layer .

(2) Materials

Furnish Materials for microduct installation, and related hardware in accordance with the Contract Documents as specified herein and manufactures installation recommendations.

- **18/14mm microduct**
 - Designed for direct bury, microtrench applications.
 - Constructed of HDPE that conforms to ASTM D3350-98a, Type III, Category 5, Class B or C and Grade P-34 per ASTM D1248-84 or equivalent.
 - Nominal outside diameter of 18mm, and a nominal inside diameter of 14mm
- **Tracer Wire for Microduct**
 - Microduct will have integrated tracer wire
 - 12 AWG, solid Copper Clad Steel (CCS)
 - HDPE or HDWPE insulation
 - UL Listed

(3) Construction Methods

Install microduct(s) having a nominal outer diameter of 18 millimeters, with all necessary fittings. City of Alexander-Engineer or representative has the right to reject any installation method proposed for a given work site.

Microduct shall be placed at the depth specified by project engineering drawings, unless otherwise specified by City of Alexander-Engineer. Where installed beneath paved roadways, microduct shall be placed in the sub-base below the roadway base layer (generally 8 to 14 inches below the paved surface). Microducts shall be installed from junction box to junction box, no couplers or midspan connections shall be used unless otherwise directed by the City of Alexandria Engineer..

Microducts shall be installed per manufacturer recommendations and specifications, including minimum bend radius and pulling tensions.

(4) HDPE Microduct

Furnish high-density polyethylene (HDPE) duct meeting the Material requirements of Section. All supplied microduct shall have an inner wall with a silicone lining and smooth outer wall. Splicing or coupling of HDPE microduct is prohibited without prior approval from City of Alexander-Engineer. All microducts shall be sealed in junction boxes and other termination locations per manufacturer specifications. Microducts shall be installed per manufacturer recommendations and specifications, including minimum bend radius and pulling tensions.

(5) Open Cut Installation in Pavement

Cut into existing pavement to create a trench with a maximum width of 1-inch and minimum of 7 inches in depth, and place microduct in the open trench. All open cutting of roadways must first be approved by City of Alexander-Engineer or representative. The conduit shall be installed by cutting a slot in the pavement with a microtrench/masonry saw. The contractor shall be responsible for the removal (e.g. vacuum or equivalent) of all cut pavement and the replacement and correction of any damaged pavement once the microducts(s) are installed.

Install HDPE microduct for all micro-trench runs, unless otherwise specified by engineering drawings. If more than one microduct is required between the same points, install microduct in one common micro-trench. If needed, install tracer wire in each trench directly above the microduct, unless microduct solution has a pre-installed tracer wire.

Remove all excavated material from the job site dispose of properly. Place the microduct against the base of the trench and anchor with self-compacting pea gravel at intervals of no more than 9-feet. Pea Gravel shall be placed in mounds no more than 3-inches tall. Fill the trench with free-flowing non-shrink grout meeting or exceeding ASTM C 1107 standards. Unless otherwise specified by City of Alexander-Engineer or representative, the trench shall be filled to match the existing finished grade.

(6) Open Trench Installation in Unpaved Surfaces:

Cut into unpaved right-of-way to create a trench with a maximum width of 1.5-inches and minimum of 7 inches in depth and place microduct in an open trench.

Install HDPE microduct for all underground runs, unless otherwise specified by engineering drawings. If more than one microduct is required between the same points, install microduct in one common micro-trench. Install tracer wire in each trench directly above the microduct, unless the microduct solution has a pre-installed tracer wire.

Place microduct flat against the base of the trench and anchor with self-compacting pea gravel at intervals no of more than 9-feet. Pea gravel shall be placed in mounds no more than 3-inches tall. For micro-trenches in unpaved right of way, the trench opening shall be filled to 3-inches below the finished grade with free-flowing nonshrink grout meeting or exceeding ASTM C 1107 standards.

The remaining 3-inches shall be filled with matching cover material and seeded with grass of the same type matching the surrounding area. Finish unpaved areas flush with surrounding natural ground.

(7) Method of Measurement

Installation shall be measured in the number of linear feet of microduct installed and accepted.

(8) Basis of Payment

The quantity of microduct installed will be paid at the Contract Unit Price per linear foot for the Pay Items listed above. Pricing shall not include microduct materials separately priced in the Material Bid Items. Trench backfill and surface restoration materials shall be considered incidental to these items.

(E) Maximum Length of Directional Drill

The length of a directional drill shall not exceed 1000 feet measured horizontally along the route of the directionally drilled conduit(s), unless otherwise approved by the Engineer. For Phase II routes longer than 1000 feet, begin a successive directional drill where the first directional drill reaches 1000 feet and install a junction box where the two directional drilled conduit runs meet. The spacing of junction boxes in a directionally drilled route shall not exceed 1000 feet.

(F) Splicing and Coupling of PE Conduit

The Contractor shall install a continuous PE conduit free from splices or couplings between junction boxes. Splicing in the middle of a directional drill operation is prohibited.

The Contractor shall install a junction box where the ends of the PE conduits meet in lieu of joining the ends through splicing and coupling. The Contractor shall install a junction box where the number of conduits in the underground run changes and where a directionally drilled conduit meets a trenched conduit. For example, install a junction box where two directionally drilled conduits meet a single run of trenched conduit. The project has budgeted four (4) JB-S2 junction boxes for this purpose. Beyond these four (4) junction boxes, the Contractor shall bear all expenses relating to additional junction boxes in lieu of joining the ends through splicing and coupling, or if he deviates from the plans.

(G) Restoration of Surface

The Contractor shall repair and restore surface areas disrupted by drilling as directed in “Unpaved Trenching” above.

3.4. MEASUREMENT AND PAYMENT

Tracer wire will be measured along the horizontal linear feet of tracer wire furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be made in linear feet. No payment will be made for excess tracer wire in junction boxes and/or cabinets.

Trench conduit (Ground) (qty) (size) will be measured in horizontal linear feet of underground conduit installation of each type furnished, installed, and accepted, without regard to the installation method. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

Trench conduit (Pavement) (qty) (size) will be measured in horizontal linear feet of underground conduit installation of each type furnished, installed, and accepted, without regard to the installation method. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

Directional drill conduit (qty) (size) will be measured horizontal linear feet of directional drill for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. When directional drilling is used where the Plans call for “Underground Conduit”, directional drilling will be measured and paid for as Underground Conduit.

Microtrenching (Ground) (qty) (size) will be measured in horizontal linear feet of microduct installation of each type furnished, installed, and accepted, without regard to the installation method. Measurement will be along the approximate centerline of the conduit system. Trench backfill and surface restoration materials shall be considered incidental to this item. Payment will be in linear feet.

No measurement will be made of vertical segments (including sweep fittings, non-metallic conduit, flexible metal conduit, and rigid galvanized steel (RGS) conduit), mechanical sealing devices or moldable sealing putty, proofing conduits with a mandrel test, pull lines (also known as a pull tape

or mule tape), and miscellaneous fittings, as these will be considered incidental to trench and directional drill conduit installation.

No measurement will be made for test holes as such work will be considered incidental to trench and directional drill conduit installation.

No measurement will be made of restoration of paved and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will be considered incidental to conduit installation. No measurement will be made of removing, stockpiling, and resetting existing granite curb, bricks, stones and pavers as such work will be considered incidental to conduit installation. The City will make no payment for a given underground conduit run until all repairs to paved and unpaved surfaces damaged/disturbed during the installation of the underground conduit have been completed and accepted.

Conduit will be paid for per linear foot based on quantity and size of conduits. As examples, an installation of a single 2" PE conduit would be paid as:

Directional Drill Conduit (1) (2") Linear Foot

No measurement or payment will be made for furnishing and installing and subsequently removing graded stone material for temporary maintenance of traffic where a portion of existing pavement has been removed as such work will be considered incidental to furnishing and installing underground conduit.

Payment will be made under:

Pay Item	Pay Unit
Tracer Wire	Linear Foot
Trench Conduit (Pavement) (1) (1.5")	Linear Foot
Trench Conduit (Pavement) (1) (2")	Linear Foot
Trench Conduit (Ground) (2) (2")	Linear Foot
Directional Drill Conduit (2) (2")	Linear Foot
Directional Drill Conduit (1) (2")	Linear Foot
Microtrenching Conduit (2) (18/14mm)	Linear Foot

4. JUNCTION BOXES

4.1. DESCRIPTION

The Contractor shall furnish and install junction boxes (aka pull boxes or fiber boxes) with covers, graded stone, grounding systems, and all necessary hardware. Modify and reuse existing junction boxes for new conduit entrance.

4.2. MATERIALS

(A) General

The work shall comply with Section 238 of the *Road and Bridge Specifications* for junction boxes.

The Contractor shall provide junction box covers with TRAFFIC logos, pull slots and stainless steel pins.

The Contractor shall not provide sealant compound between junction boxes and covers.

The junction boxes and covers shall conform to the requirements of ANSI/SCTE 77 2007 and Tier 15 loading. The junction boxes shall be open bottom.

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's PATCDL.

(B) Junction Box (JB-S2)

The Contractor shall provide junction boxes (VDOT standard box JB-S2) with covers for cable pulling, with minimum inside dimensions of 30"(l) x 17"(w) x 30"(d) that meet or exceed the requirements of Section 238. JB-S2 junction boxes shall be Polymer concrete with straight sides or boxes with Polymer concrete frames (also referred to as rings) and covers with flared or straight fiberglass sides.

(C) Junction Box (JB-S3)

The Contractor shall provide junction boxes (VDOT standard box JB-S3) with covers for cable pulling, cable storage and splice enclosures, with minimum inside dimensions of 36"(l) x 24"(w) x 36"(d) that meet or exceed the requirements of Section 238. JB-S3 junction boxes shall be fiberglass with flared fiberglass sides. The frames (also referred to as rings) and covers shall be Polymer concrete. A J-hook wire support shall be installed six inches below the top as per *VDOT Road and Bridge Spec.* pg. 1317.20

4.3. PROCEDURES

(A) General

The Contractor shall comply with Article 700 of the Road and Bridge Specifications for junction boxes, except as noted below:

Section 700.04(i) Junction Box Covers is replaced with the following:

(i) **Junction Boxes** shall be installed as follows:

The junction box site shall be excavated such that the depth of the excavation shall be the height of the junction box plus at least twelve inches to allow for bedding aggregate material and such that the width shall be six to eight inches wider than the junction box.

Bedding material shall be No. 68, No. 78, or No. 8 aggregate conforming to No. 78, or No. 8 gradation requirements. Aggregate shall be a minimum of twelve inches in depth and entirely cover the bottom of the junction box excavation. The bedding aggregate shall be leveled and tamped prior to installing the junction box.

Junction box shall be installed and leveled to grade prior to backfilling.

Prior to backfilling the interior of polymer concrete junction boxes (JB-S2 and JB-S3) shall be braced internally with 2 inch by 4 inch lumber using two braces across the width and one brace across the length of the box or as required by the manufacturer. Bracing shall be installed to facilitate removal once back filling and compaction have been completed. The Contractor shall remove internal bracing after the backfilling and compacting operation has been completed.

The cover of the junction box shall be installed prior to backfilling.

The junction box shall be backfilled and compacted around its perimeter utilizing six to eight inch horizontal lifts to where the concrete collar is to begin. Once the concrete collar has cured, the remaining area around the collar shall be backfilled and compacted as stated above. Compaction shall be at least ninety percent of the theoretical maximum density as defined in Section 101.02 of the Specifications. A mechanical tamping device shall be used to compact the backfill and soil layer by layer around the perimeter of the junction box. The wheel of a backhoe or other type vehicle shall not be used for compaction of backfill and soil. The internal bracing shall be removed after backfilling and compaction has been completed. The area around the junction box shall be graded and restored as stated in the VDOT Specifications.

Junction boxes shall not be installed or backfilled in standing water. Backfill material shall be free of large stones, wood, or other debris and shall not be saturated with water. If a special tool or wrench is required to remove the cover, the Contractor shall furnish the Engineer with five such tools.

The Contractor shall install junction boxes flush with finished grade. The Contractor shall not install sealant compound between junction boxes and covers.

The Contractor shall not install concrete collars in areas surrounded by brick or masonry work.

Upon completion of junction box installation and backfilling of all excavations, the Contractor shall restore the disturbed ground to its original condition as determined and approved by the Engineer. For paved areas, the Contractor shall replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish, and general appearance of the surrounding pavement. Refer to Section 1 of these Project Special Provisions for additional requirements

concerning sidewalks and curbs in historic districts. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. The Contractor shall finish unpaved areas flush with surrounding natural ground to match the original contour of the ground. The Contractor shall seed with the same type of grass as the surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

The Contractor shall complete restoration of all ground disturbed during junction box installation within five consecutive calendar days following initial removal and excavation. If the Contractor fails to repair and restore the disturbed ground in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the ground will be deducted from payment due the Contractor, plus \$500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

The Contractor shall install fiber boxes (JB-S3) where underground splicing of cable is necessary and where transitioning from below ground to above ground installation or vice-versa.

The Contractor shall install fiber boxes (JB-S3) in underground fiber-optic communications cable runs at each traffic signal, or where shown in the Plans. For existing conduit routes, install fiber box at each traffic signal as shown in the Plans.

(B) GPS Coordinates

The Contractor shall provide real world coordinates for all junction boxes and equipment cabinets installed or utilized under this project. Provide the coordinates in conformance with the *VDOT Geo-Spatial Data Delivery Recommendations*. The Contractor shall furnish coordinates that do not deviate more than 1.7 feet in the horizontal plane and 3.3 feet in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Submit cut sheets on the GPS unit proposed to collect the data for approval by the Engineer.

The Contractor shall provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, City system ID number) in the Microsoft Excel spreadsheet using the format shown in example below.

City Sys ID#	Name	Location	Latitude	Longitude	Manufacturer	Model #
	Equipment Cabinet	Elm St. at Oak Dr.	-78.5500	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 1 (Phase 2 Side)	Elm St. at Oak Dr.	-78.5516	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 2 (Phase 2 Side)	Elm St. at Oak Dr.	-78.5506	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 3 (Near Cabinet)	Elm St. at Oak Dr.	-78.5501	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 4 (Phase 6 Side)	Elm St. at Oak Dr.	-78.5486	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 5 (Phase 6 Side)	Elm St. at Oak Dr.	-78.5493	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 6 (Phase 4 Side)	Elm St. at Oak Dr.	-78.5503	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)

(C) Modified Junction Boxes

At certain locations identified in the plans, conduits for CCTV cables shall be routed into existing junction boxes that may house existing loop wires, splices, and lead-in cables. Modify such existing junction boxes by installing a new conduit entrance for the new Hybrid Camera Cable and/or fiber-optic cables. Perform necessary work to install the new conduit entrance, including but not limited to excavating around edges of junction box, removing and resetting junction box, and replacement of crushed stone base removed to install conduit. Take necessary precautions to prevent damage to the existing conduits and cables located in these existing pull boxes. The Contractor shall be solely responsible for any damage or displacement of the cable, conduit, or junction box arising out of or related to the Contractor's activities.

When an existing junction box that is to be modified or cables and conduits contained therein are found to have existing damage or found to be displaced, the Contractor shall report the conditions to the Engineer before beginning work at that location so as not to be held responsible for the existing damage. Junction boxes with damaged or missing covers are considered damaged junction boxes. The Engineer will determine whether to have City forces repair or replace the existing junction box prior to the Contractor's work or have the contractor replace the damaged junction box with a new junction box at the contract unit price for junction boxes.

(D) Remove Junction Boxes

Excavate around the existing junction box such that the depth of the excavation shall be the height of the existing junction box and such a width as to accommodate the proposed junction box. Remove the existing junction box without damaging existing conduit, fiber-optic cables, tracer wire or grounding equipment. Dispose of existing junction box as directed by the Engineer.

4.4. MEASUREMENT AND PAYMENT

Junction Box (JB-S2) will be measured and paid in actual number of fiber pull/junction boxes of each size and type furnished, installed, and accepted.

Junction Box (JB-S3) will be measured and paid in actual number of fiber pull/junction/splice boxes of each size and type furnished, installed, and accepted.

Modified Junction Box will be measured and paid in actual number of junction boxes modified and accepted.

Remove Junction Box will be measured and paid in actual number of junction boxes removed.

No measurement will be made for covers, concrete collars, curb markers on covers, graded stone, removal of existing junction boxes and grounding systems as these will be considered incidental to furnishing and installing junction boxes.

No measurement will be made of restoration of paved and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will be considered incidental to junction box installation. The City will make no payment for a given junction box until all repairs to paved and unpaved surfaces damaged/disturbed during the installation of the junction box have been completed and accepted.

No measurement will be made of collecting and recording GPS coordinates for junction boxes and compiling this data in the prescribed Microsoft Excel spreadsheet as such work will be considered incidental to furnishing and installing junction boxes.

Payment will be made under:

Pay Item	Pay Unit
Junction Box (JB-S2)	Each
Junction Box (JB-S3)	Each
Modified Junction Box	Each
Remove Junction Box	Each

5. FIBER-OPTIC CABLE

5.1. DESCRIPTION

The Contractor shall furnish and install single mode fiber-optic (SMFO) communications cable and drop cables with grounding systems, communications cable identification markers, and all necessary hardware. All fiber splices shall be fusion spliced. Connectors installed on fibers shall be of the fusion-splicable type. Mechanical splices or connectors or splicing that rely on index matching gel shall not be accepted.

5.2. MATERIALS

(A) SMFO Communications Cable

The Contractor shall furnish single-mode fiber-optic communications cable of the size shown on the Plans. The Contractor shall furnish fiber-optic cable that is all dielectric and gel-free.

The Contractor shall furnish loose tube fiber-optic cable with required fiber count that complies with RUS CFR 1755.900, single mode with dielectric central member. The Contractor shall use single mode fiber in cable that does not exceed attenuation of 0.25 dB/km at 1550 nm and 0.35 dB/km at 1310 nm. The Contractor shall provide cable with all fibers that are useable and with surface sufficiently free of imperfections and inclusions to meet optical, mechanical, and environmental requirements. The Contractor shall provide cable with minimum of one ripcord under sheath for easy sheath removal and with shipping, storage, installation, and operating temperature of at least -40 to 160 degrees F with a dual layered, UV cured acrylate fiber coating applied by cable manufacturer that may be stripped mechanically or chemically without damaging fiber.

The Contractor shall provide fibers inside loose buffer tube. The Contractor shall use cable with doped silica core surrounded by concentric silica cladding for each fiber. The fiber optic cable shall distinguish each fiber and buffer tube from others by means of color-coding that meets EIA/TIA-598C *Color Coding of Fiber-Optic Cables*. The Contractor shall provide exactly 12 fibers per buffer tube in all cables. In buffer tubes that contain multiple fibers, the cable colors shall be stable during temperature cycling and not subject to fading, sticking, or smearing into each other or into water-blocking filling material. The selected cable shall use fillers in cable core if necessary to provide a symmetrical cross-section of cable. The cable shall have buffer tubes filled with super-absorbent, water-blocking material that is non-hygroscopic, non-nutritive to fungus, electrically non-conductive and homogenous.

The Contractor-provided cable shall have a central member consisting of a dielectric glass reinforced plastic rod. The cable shall apply binders with sufficient tension to secure buffer tubes and binders to the central member without crushing buffer tubes. The selected cable shall be made to ensure that binders are non-hygroscopic, non-wicking (or rendered so by the water-blocking compound), and dielectric with low shrinkage.

The Contractor shall provide cable that has cable core interstices filled with super-absorbent, water blocking compound that is non-conductive and homogenous. The selected cable shall be made to ensure compound is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

The Contractor shall provide cable with high tensile strength aramid yarns or fiberglass yarns that are helically stranded evenly around cable core.

The Contractor-provided cable jacket shall be of consistent thickness that is free of holes, splits, and blisters, and contains no metal elements. The cable shall have an outer jacket of medium density polyethylene with minimum nominal sheath thickness of 0.050 inch. The Contractor shall ensure that the cable polyethylene contains carbon black for ultraviolet light protection and does not promote fungus growth.

The Contractor-provided cable shall have length markings in sequential feet and within one percent of actual cable length. The cable provided shall have a character height that is approximately 0.10".

The Contractor-provided cable shall have "City of Alexandria" stamped into the cable jacket. The cable provided shall have a character height that is approximately 0.10". The Contractor shall submit a sample of proposed communications cable to the Engineer for approval before installation.

(B) Pre-Terminated Drop Cable Assembly for CCTV Installations

The Contractor shall furnish pre-terminated drop cable assemblies to provide communications links between splice enclosures and Ethernet edge switches mounted in signal cabinets at proposed CCTV locations. The Contractor shall be fully and solely responsible for determining the proper length of each pre-terminated drop cable. Re-ordering of drop cable assemblies caused by Contractor miscalculation of length shall not be reimbursed by the City.

The Contractor shall furnish drop cables that comply with RUS-CRF 1755.900 and have a minimum bend radius of at least 5 inches. Further, the Contractor shall ensure the drop cable has the same operating characteristics as the SMFO cable to which it is coupled.

The Contractor shall select a cable with an attenuation drop at 1310 nm that does not exceed 0.5 dB/km. The Contractor shall ensure attenuation loss for complete drop cable does not exceed a mean value of 1.5 dB.

The Contractor shall provide an assembly that is factory pre-assembled and factory pre-tested with the necessary drop cable length. The Contractor shall furnish a drop cable assembly comprised of the designated length of fiber-optic cable that has been factory pre-terminated on a factory pre-connectorized patch panel with four LC-UPC connectors matching the Ethernet edge switch to form

an integral pre-assembled unit. The Contractor shall furnish a drop-cable assembly that requires no field assembly, connectorization, or termination other than splicing the free end of the drop cable into the fiber-optic trunk cable in a splice enclosure external to the cabinet. The Contractor shall cap all unused LC connectors.

The Contractor shall provide a drop cable assembly with a patch panel in a compact, surface-mountable modular housing. The compact modular patch panel shall have a rugged, durable, non-metallic housing that can be surface-mounted vertically to the face of a back plate mounted to the side of a cabinet. The dimensions of the patch panel shall not exceed 9" (l) x 2" (w) x 2" (h). The Contractor shall furnish and install a 1/16th inch thick aluminum back plate in signal cabinets equipped with CCTV cameras. The back plate shall be of sufficient width and height to mount the patch panel. Back plate can be an integral component of the pre-terminated drop cable assembly as long as the back plate can be solidly fastened to in the controller cabinet.

(C) Flat Drop Cable for Passive Network

The contractor shall furnish a bend-insensitive single fiber, gel free, toneable, flat drop cable suitable for underground use in ducts to provide communications links between the passive splice enclosures and the ONT mounted in the controller cabinets. The Contractor shall be fully and solely responsible for determining the proper length of each flat drop cable. Re-ordering of flat drop cable caused by Contractor miscalculation of length shall not be reimbursed by the City. The Contractor shall ensure the flat drop cable has the same operating characteristics as the SMFO cable to which it is coupled. The contractor shall ensure the flat drop cable complies with all requirements of the splice enclosure and be terminated with an SC-APC connector for connection to the SC-APC bulkhead panel in the splice enclosure. The opposite end of the flat drop cable can either be terminated with an SC-APC connector to connect directly to the ONT input coupler or be fusion spliced to an SC-APC pigtail in the ONT splice tray of the mounting bracket. The SC-APC pigtail connector would then be connected to the ONT input coupler.

(D) Fabric Inner-duct

The Contractor shall furnish and install fabric inner-duct in all existing conduit that contains existing cables and where proposed fiber-optic trunk cables (96-fiber SMFO cable) are to be installed. The fabric inner-duct shall be two or more individual cells sized appropriately to the existing conduit, with an integral measuring pull line, that is pre-lubricated and resistant to petroleum products and ground chemicals.

(E) Proofing Existing Conduits

The Contractor shall perform a mandrel test on empty existing conduits to ensure conduit is not damaged (this is also referred to as "proofing" the conduit). The Contractor shall furnish non-metallic mandrel with a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, the Contractor shall proof the conduit from the other direction to determine the length and location of the blockage. Following this, the Contractor shall

notify the Engineer before attempting to relieve the damage/blockage with a reamer. If the reamer fails to relieve the blockage, the Contractor shall notify the Engineer and get permission to replace the damaged length of conduit and ensure that a pull line (also known as a pull tape or mule tape) is installed.

(F) Pull Line

The Contractor shall install a pull line (also known as a pull tape or mule tape) simultaneously in a continuous length with the fiber-optic cable and tracer wire. If installing fabric inner-duct, the Contractor shall install the pull line simultaneously with the fabric inner-duct. The Contractor shall store 3 feet of pull line (for each pull line) in junction boxes.

5.3. PROCEDURES

(A) General

The Contractor shall provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable.

The Contractor shall install SMFO communications cable, communications cable identification markers, and all necessary hardware.

The Contractor shall comply with manufacturer's recommendations. The Contractor shall install communications cable in conduits as required to bring the fiber-optic cable into and, if necessary, out of each termination cabinet.

The Contractor shall take all precautions necessary to ensure cable is not damaged during storage, handling, and installation. The Contractor shall not violate minimum bending radius of 20 times the radius of cable diameter or manufacturer's recommendation, whichever is greater. Contractor personnel or subcontractors shall not step on cable nor run over cable with vehicles or equipment. The Contractor shall not pull cable over or around obstructions, or along the ground. The contractor shall not pull cable from a conduit opening at an angle relative to the opening unless a device is utilized that relieves the lateral stress on the fiber such as a pulley system.

The Contractor shall determine lengths of cable necessary to reach from termination-point to termination-point. The Contractor shall install cable in continuous lengths between approved facilities. Additionally, the Contractor shall provide a sufficient amount of slack cable to allow for an additional 10 feet of cable to be present after removal of outer sheath for termination. The Contractor shall measure slack cable by extending cable straight out of communications hub cabinet door. No splicing shall be permitted at any field cabinets other than communications termination cabinets.

The Contractor shall keep cable ends sealed at all times during installation to effectively prevent the ingress of moisture. The Contractor shall keep the flat drop cable fusion spliced to pigtail

connector in splice tray of ONT mounting bracket. The Contractor shall use approved heat shrink cable end cap and shall not use tape to seal cable ends.

Before installing cable, the Contractor shall provide three copies of cable manufacturer's recommended and maximum pulling tension. The Contractor shall not exceed manufacturer's recommended pulling tension. The Contractor shall make use of pulling grips containing a rotating swivel. Cable shall be coiled in a figure-8 configuration whenever cable is unreeled for subsequent pulling.

The Contractor shall seal all conduits containing fiber-optic communications cable in junction boxes and cabinet bases with mechanical sealing devices or moldable sealing putty. The Contractor shall comply with the requirements for mechanical sealing devices and moldable sealing putty in the "Underground Conduit" section of these Project Special Provisions

(B) Underground Installation

The Contractor shall install fiber-optic cable underground in conduit using cable pulling lubricants recommended by the fiber-optic cable manufacturer. Where more than one fiber-optic cable is being installed in a multiple conduit underground run, the Contractor shall ensure that at least one conduit remains empty for future use by installing more than one cable in a conduit as needed, unless directed otherwise by the Engineer.

The Contractor shall obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

The Contractor shall make use of a breakaway swivel so as not to exceed 80% of the maximum allowable pulling tension specified by the cable's manufacturer if cable is pulled by mechanical means.

The Contractor shall keep tension on cable reel and pulling line at start of each pull. Do not release tension if pulling operation is halted. Restart pulling operation by gradually increasing tension until cable is in motion.

The Contractor shall feed cable by manually rotating the reel for pulling cable through manholes, junction boxes, and vaults. The Contractor shall not pull cable through intermediate junction boxes, handholds, or openings in conduit unless otherwise approved.

Inside all junction boxes, the Contractor shall install communications cable identification markers on each communications cable entering the junction box.

The Contractor shall store at least 25 feet of each fiber-optic cable for each cable run as shown in the Plans, unless otherwise indicated. The Contractor shall provide 100 feet of cable at junction boxes

located at traffic signals to be integrated into the fiber-optic communication network in future project stages.

In a junction box where a splice enclosure may be required in the future, the Contractor shall store 100 feet of fiber-optic cable intended for the splice as indicated on the Plans.

(C) Installation of Drop Cable Preterminated Drop Cable Assembly for CCTV Active Network

The Contractor shall verify the length of pre-terminated drop cable needed, including slack, to reach from termination point to termination point.

The Contractor shall splice the free end of the drop cable into the fiber-optic trunk cable in a splice enclosure external to the cabinet.

At below ground splice enclosures, the Contractor shall coil slack cable as shown in plans for each cable entering and exiting the splice enclosure in the manhole or junction box where enclosure is located. The Contractor shall coil and store any drop cable in excess of what is needed for storage in the manhole or junction box in the base of the equipment cabinet. Where fiber-optic cables are installed but not immediately spliced, the Contractor shall store fiber-optic trunk cable (as shown on plans) inside the manhole or junction box to facilitate subsequent splicing in the splice enclosure. The Contractor shall cap and seal ends of cables that have yet to be spliced or terminated with a waterproof heat-shrink cap/seal as approved by the Engineer.

The Contractor shall label all connectors, pigtails and the connector panel. At the underground splice location, the Contractor shall cap off all unused fibers and label to correspond with the connector panel.

The Contractor shall use an OTDR (with up to date equipment calibration certification stamp and copy of calibration shall be provided to City representative for validation), to test the end-to-end connectivity of the drop cable from patch panel installed inside the equipment cabinet to the opposite end of installed fiber run. The Contractor shall comply with the OTDR testing and reporting requirements of the "Fiber-Optic Splice Centers" section of these Project Special Provisions when testing drop cable.

(D) Installation of Flat Drop Cable for Passive Network

The Contractor shall verify the length of flat drop cable needed, including slack, to reach from termination point to termination point.

The Contractor shall install the cable between the passive-use splice enclosure and the ONT. The Contractor shall label all connectors, pigtails and the connector panel. At the underground splice location, the Contractor shall cap off all unused bulkhead couplers.

The Contractor shall use an OTDR (with up to date equipment calibration certification stamp and copy of calibration shall be provided to City representative for validation), to test the end-to-end connectivity of the drop cable from ONT input coupler installed inside the equipment cabinet to the originating PON splitter location. The Contractor shall comply with the OTDR testing and reporting requirements of the “Fiber-Optic Splice Centers” section of these Project Special Provisions when testing flat drop cable.

(E) Testing and Acceptance

The Contractor shall comply with the testing requirements for fiber-optic cable (SMFO 96-fiber and drop cable) as defined in Section 19.3 of these project special provisions. The Engineer shall make a determination of acceptance following inspection of the fiber-optic cable and fabric inner-duct installation and review of the fiber-optic test results.

5.4. MEASUREMENT AND PAYMENT

SMFO cable (96-fiber) will be measured and paid as the actual linear feet of fiber-optic cable of each fiber count furnished, installed, tested, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all fibers before determining length of cable run. A payment of 60 percent will follow installation. The remaining 40 percent will follow testing and acceptance.

Pre-Terminated Drop Cable Assembly for CCTV Installations will be measured and paid as the actual number of pre-terminated fiber-optic drop cable assemblies furnished, installed, tested, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow testing and acceptance.

Fabric Inner-duct will be measured and paid as the horizontal linear feet of the underground conduit from junction box to junction box, furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. No measurement will be made of vertical segments. A payment of 60 percent will follow installation. The remaining 40 percent will follow acceptance.

Flat Drop Cable for Passive Network will be measured and paid as the actual number of flat drop cables furnished, installed, tested, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow testing and acceptance.

No measurement will be made for terminating, splicing, and testing fiber-optic cable, communications cable identification markers, proofing conduits with a mandrel test, pull lines (also known as a pull tape or mule tape), aluminum back plates, SMFO jumpers and pigtails, mechanical sealing devices and conduit seals/sealing putty, as these will be considered incidental to the installation of fiber-optic cable and drop cables.

Payment will be made under:

Pay Item	Pay Unit
SMFO Cable (96-Fiber)	Linear Foot
Pre-Terminated Drop Cable Assembly for CCTV Installations	Each
Fabric Inner-duct	Linear Foot
Flat Drop Cable for Passive Network	Linear Foot

6. FIBER-OPTIC SPLICE CENTERS

6.1. DESCRIPTION

The Contractor shall furnish and install fiber-optic interconnect centers, termination cabinets, splice enclosures, cabinet foundations and all necessary hardware. The Contractor shall furnish one 144 position interconnect center in each termination cabinet.

6.2. MATERIALS

(A) Interconnect Center

The Contractor shall furnish compact, modular interconnect centers designed to be flush mounted inside 19" equipment racks. Design and size interconnect centers that shall accommodate all fibers entering racks. Provide interconnect center housings that shall enclose connector panels for equipment racks that are 4 rack units (RU) high or smaller. Provide splice tray housings that shall be 3 rack units (RU) high or smaller.

Provide splice trays that shall hold, protect, organize optical fibers, and secure fibers inside splice tray. The Contractor shall size and provide splice trays to be dielectric, to accommodate all fibers entering splice tray, and to provide sufficient space to prevent microbending of optical fibers. Provide connector panels that shall use LC-UPC type connectors for active network CCTV connections.

For the CCTV Active network connections, the contractor shall furnish SMFO pigtails with each interconnect center. Provide pigtails containing connector panels that are a maximum of six feet in length with a factory-assembled LC-UPC connector on one end. The Contractor shall ensure SMFO pigtails meet the operating characteristics of the SMFO cable with which it is to be coupled.

The Contractor shall furnish SMFO jumpers that are a minimum of 3 feet in length with factory assembled LC-UPC connectors on each end. The Contractor shall ensure that SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

For the Passive Optical Network connections, the contractor shall furnish SMFO pigtails establishing connections between the designated PON splitter input or output and the appropriate splice tray of the interconnect center. The pigtail shall have a factory-assembled SC-APC connectors for connection to the splitter and be fusion-spliced to the fiber optic cable of the splice tray. The pigtail shall be minimally constructed with a 900-micron color-coded buffer tube and be additionally protected from physical damage outside of the splice tray. Alternatively, pigtail can be constructed with a 3mm jacket but must be properly identified. The Contractor shall ensure SMFO pigtails meet the operating characteristics of the SMFO cable with which it is to be coupled.

(B) Termination Cabinet

The Contractor shall provide a Type 336S cabinet assembly with a removable, standard 19-inch EIA compliant rack mounting splice enclosures and connector panel housings at the field locations shown in the Plans. Provide an aluminum base adapter (8" high minimum) to raise cabinet off grade.

Use permanent, flexible waterproof sealing material to:

- Seal between cabinet base and cabinet base adapter/extender,
- Seal two-piece cabinet base adapter/extender seams, and

- Seal space between cabinet base adapter/extender and foundation

(C) Cabinet Foundation

Furnish and Install cabinet foundations in accordance with Standard Drawing 1301.10 of the Road and Bridge Standards. Furnish cabinet foundations with chamfered top edges. Provide minimum Class B concrete.

(D) Splice Enclosure for CCTV Active Network and/or Full Splice Location

The Contractor shall furnish splice enclosures that are re-enterable using a mechanical dome-to-base seal with a flash test valve, and are impervious to the entry of foreign material (water, dust, etc.). The Contractor shall ensure enclosures are manufactured in such a manner to be suitable for junction box and manhole installation. Provide enclosures with a minimum of two oversized ports that shall accept one trunk cable per port and with a minimum of four round ports (captive ports for single cables) that shall accommodate all cables entering enclosure. The splice enclosure shall employ a gel type sealing block with a compression trigger to effectively seal the base of the enclosure.

Provide heat shrink cable shields, or gasket seals, with enclosure that shall ensure weather-tight seal where each cable enters enclosure.

The Contractor shall be responsible for properly sizing each individual splice enclosure. Within enclosures, the Contractor shall provide enough re-enterable, mountable splice trays to accommodate the number of splices specified in the plans, plus the capacity to house additional splice trays for splicing the entire trunk cable. The Contractor shall provide a fiber containment basket for storage of loose buffer tubes expressed (i.e., uncut and unspliced) through the enclosure. The Contractor shall ensure that enclosures shall allow sufficient space to prevent microbending of buffer tubes when coiled. The Contractor shall ensure that the splice enclosure has sufficient volume to accommodate the splice trays and containment basket.

Provide splice trays that shall hold, protect, organize optical fibers, and secure fibers inside splice tray. Provide splice trays that shall be dielectric material.

(E) Splice Enclosure for Passive Network

The Contractor shall furnish splice enclosures that are re-enterable, are impervious to the entry of foreign material (water, dust, etc.) and have two distinct, separately hinged compartments, Splice and Access, separated by a bulkhead panel. The splice compartment shall have four cable entry ports and be capable of splicing mid-span accessed 144 count fiber cable, utilizing up to three 24 count splice trays for a splicing capacity of up to 72 individual splices. The contractor shall fusion splice SC-APC pigtails to the appropriate fiber in the splice tray and terminate to the splice compartment side of the SC-APC bulkhead panel. The separately hinged, access compartment shall be capable to anchor and connect up to twelve individual flat drop cables and create a water-tight seal around the drop cables with the door closed through gel or other similarly cured material used as a sealing mechanism. The drop cables shall be terminated to the access compartment side of SC-APC bulkhead panel. The splice enclosure shall be constructed of UV stabilized black plastic and be suitable for underground use in a handhole and complying with IP67 and IP68 testing standards. The enclosure shall also have the capability to have both trunk cables and all flat drop cables enter and exit the same side of the enclosure.

(F) 2x32 PON Splitter

The Contractor shall furnish an optical splitter with two SC-APC inputs and thirty-two SC-APC outputs housed in a 1U, 19", rack-mountable, metal enclosure. All SC-APC input and output connections shall be located on a flat, flush-mount, front panel. Splitter shall utilize PLC splitter technology and G.657A type fiber. Insertion Loss shall be 17.5dB or better. Uniformity Loss shall be 1.8dB or better. Return Loss shall be 50dB or better. Splitter shall have an operating temperature range of -40 to +85 degrees C. All unused SC-APC splitter output ports shall be terminated with a low reflection SC-APC terminator connectors.

6.3. PROCEDURES

(A) General (Workmanship Identification Information)

The Contractor shall include on the cover of each splice tray in a legible format the following information:

- Splice location reference # or identification information (e.g., 04-xxxx tray 1 of 3, 04-xxxx tray 2 of 3, etc.);
- Date the splice was made;
- Name of company name that performed the splicing;
- Name of person who performed the splicing.

(B) Workmanship

Upon cutting the cable and removing the outer jacketing material down to the individual buffer tubes, the Contractor shall secure the central strength member to the enclosure so that no tensile force is applied to the fibers. The Contractor shall secure the individual buffer tubes to the splice trays by a method recommended by the manufacturer. The Contractor shall determine the length of each buffer tube needed to ensure that the buffer tube can be looped a minimum of two times around the inside of the splice tray. Upon determination of the length of buffer tube needed, the Contractor shall remove the buffer tube to expose the individual fibers for fusion splicing. Adjust individual fiber lengths as necessary to ensure that once the fusion splicing process is completed, the finished splices shall align with the "splice block organizer" supplied within the splice tray. The Contractor shall ensure the splice block organizer has individual fusion splice space holders for each fiber splice. The unused end of the individual fiber that was cut and spliced shall have sufficient length coiled in the splice tray to be utilized in a potential future splice.

While prepping the individual fibers for splicing, the Contractor shall install the fusion splice sleeve over the fiber and then perform the splicing operations, following the manufacturer's instructions. Verify that the newly formed splice does not exceed 0.1 dB of attenuation. If the attenuation is more than 0.1 dB, then the Contractor shall remake the splice until it meets the 0.1 dB or less requirement. The Contractor shall finish the splicing operation by sliding the fusion splice sleeve over the splice and applying heat to active the heat shrink tubing. Secure the finished splice in the splice block organizer. The Contractor shall ensure each splice is properly secured in a space holder in the splice block organizer. Multiple splices secured in the same splice holder slot are unacceptable.

The Contractor shall ensure all buffer tubes are contained within splice trays so that no bare fibers are outside of the tray. The Contractor shall not damage the fibers and shall not violate the minimum bend radius of the fiber.

Prior to installing the cover over the splice tray and placing it in its final resting location, the Contractor shall take a MANDATORY digital photograph of the splice tray that shows the final workmanship. The Contractor shall ensure that the photograph shows the “Workmanship Identification Information” as well as the workmanship associated with installing and terminating the fiber. The Contractor shall include digital copies of each photograph on a compact disc as part of the OTDR Test Results submittal.

(C) Interconnect Center

The Contractor shall install interconnect centers with connector panels, splice trays, storage for slack cable or fibers, mounting and strain relief hardware, and all necessary hardware.

The Contractor shall terminate and fusion splice all fibers as shown in the Plans.

The Contractor shall label all fiber-optic connectors, whether on jumpers, connector panels, or other equipment, to prevent improper connection. The Contractor shall obtain approval of fiber-optic connector labeling method before starting work.

All fibers designated for termination to a connector panel within an interconnect center shall fusion splice the fibers to pigtails.

All fibers designated to pass through an interconnect center shall be neatly coiled and express the fibers without cutting.

All buffer tubes designated to pass through interconnect center shall have neatly coiled excess tubing inside interconnect center.

The Contractor shall install SMFO jumpers between the appropriate connectors on the interconnect center and the edge switch.

(D) Termination Cabinet

The Contractor shall mount the fiber-optic termination cabinets on concrete foundations. Route the fiber-optic cables into the cabinet and secure them to the internal communications rack. Install the fiber-optic splice and connector housings in a logical manner.

Provide the interior of the cabinet with ample space for housing all associated equipment and wiring; use no more than 75% of the useable space in the cabinet. Provide ample space in the bottom of the cabinet for the entrance and exit of all power, communications, and grounding conductors and conduit.

(E) Cabinet Foundations

Obtain approval for final cabinet foundation locations before pouring concrete base or installing a preformed cabinet base. Locate new cabinets so as not to obstruct sight distance of vehicles turning on red or create any ADA violations or pedestrian conflicts. Maintain 12 inches minimum from service pole to closest point on foundation unless otherwise approved.

Do not install foundations over uncompacted fill or muck. Hand tamp soil before placing concrete or preformed cabinet base and ensure ground is level.

When using poured concrete foundations, use procedures, equipment, and hardware as follows:

- In unpaved areas, install cabinet foundations a minimum 4 inches above and 4 inches below finished grade. In paved areas, install foundations 1 inch above the paved surface at its highest point and 4 inches below the paved surface at its lowest point.
- Locate external stubbed out conduit at cabinet foundation so conduit is in middle of cabinet. Provide service conduit as the rightmost conduit coming into cabinet. Provide two spare conduits stubbed out; one pointed toward service pole and the other toward direction of lead-in cable. Inscribe identification arrow in foundation indicating direction of spare conduits.
- Ensure that conduits extend 2" to 3" above finished cabinet foundation.
- Give cabinet foundation a broom finish. Seal space between cabinet base and foundation with permanent, flexible, waterproof sealing material.

Upon completion of cabinet foundation installation and backfilling of all excavations, the Contractor shall restore the disturbed ground to its original condition as determined and approved by the Engineer. For paved areas, the Contractor shall replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish, and general appearance of the surrounding pavement. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. The Contractor shall finish unpaved areas flush with surrounding natural ground to match the original contour of the ground. The Contractor shall seed with the same type of grass as the surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

(F) Splice Enclosure

The Contractor shall install splice enclosures with splice trays, basket containment assemblies, racking for slack cable or fibers, mounting and strain relief hardware, and all other necessary hardware.

The Contractor shall fusion splice all fibers including fibers designated to be coupled with fibers from a drop cable. All fibers designated to pass through splice enclosure shall be coiled and express the fibers without cutting.

All buffer tubes designated to pass through splice enclosure shall have neatly coiled excess tubing inside basket provided with enclosure.

The Contractor shall label all fiber-optic splices and shall obtain approval of fiber-optic connector labeling method.

The Contractor shall install heat shrink cable shields using methods recommended by the manufacturer of the enclosure. A pressurization flash test shall be performed on the enclosure in accordance with manufacturer's recommended procedures at the conclusion of splicing procedure and before final placement of enclosure.

The Contractor shall install enclosures with enough slack cable to allow enclosure to be extended into a splicing vehicle.

For underground, manhole, and junction box installations, the required spare cable shall be neatly coiled and tie-wrapped at the bottom of the junction box or neatly placed in the manhole racks. The splice enclosure shall be fastened in place to the J-hook or other fastening means near the top of the junction box or manhole with the cable entry ports down.

(G) Testing and Acceptance

The Contractor shall comply with the general testing requirements as defined in Section 19 of these project special provisions and as defined in this section.

The Engineer shall make a determination of acceptance following inspection of the interconnect centers installation and review of the fiber-optic test results.

The Engineer shall make a determination of acceptance following inspection of the termination cabinets installation.

The Engineer shall make a determination of acceptance following inspection of the installed cabinet foundations.

The Engineer shall make a determination of acceptance following inspection of the splice enclosures installation and review of the fiber-optic test results.

The Contractor shall provide written notification to the Engineer a minimum of 15 working days before beginning the OTDR tests.

After splicing is completed, the Contractor shall perform bi-directional OTDR tests on each fiber, including unused fibers. The Contractor shall install a 1000-foot pre-tested launch cable between the OTDR and fiber-optic cable to be tested.

The Contractor shall ensure fusion splice losses do not exceed 0.1 dB and connectors have a loss of 0.5 dB or less. If any fiber exceeds maximum allowable attenuation or if fiber-optic properties of the cable have been impaired, take appropriate actions up to and including replacement of the fiber-optic cable. Corrective action shall be at no additional cost to the City.

Clearly label each OTDR trace identifying a starting and ending point for all fibers being tested. Record the attenuation level of each fiber and clearly indicate OTDR trace results in report format. The Contractor shall furnish one hard copy of each of the OTDR trace results and electronic copies of all trace results along with digital photographs showing workmanship for each splice on a compact disc. The Contractor shall furnish the manufacturer's make, model number, and software version of the OTDR used for testing.

6.4. MEASUREMENT AND PAYMENT

Interconnect center (144-position) will be measured and paid as the actual number of fiber-optic interconnect centers furnished, installed, tested, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow testing and acceptance.

Termination cabinet will be measured and paid as the actual number of termination cabinets furnished, installed, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow acceptance.

Cabinet foundation will be measured and paid as the actual number of signal cabinet foundations furnished, installed, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow acceptance.

Splice enclosure for CCTV Active Network will be measured and paid as the actual number of fiber-optic splice enclosures that are furnished, installed, tested, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow testing and acceptance.

Splice Enclosure for Passive Network will be measured and paid as the actual number of fiber-optic splice enclosures that are furnished, installed, tested, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow testing and acceptance.

No measurement will be made of fusion splices, splice trays, splice protectors, pigtails, jumpers, connector panels, labeling, testing and photographs as these will be considered incidental to installing interconnect centers.

Payment will be made under:

Pay Item	Pay Unit
Interconnect Center (144-position)	Each
Termination Cabinet	Each
Cabinet Foundation	Each
Splice Enclosure for CCTV Active Network	Each
Splice Enclosure for Passive network	Each
Remove Splice Enclosure	Each

7. UNDERGROUND CABLE MARKERS

7.1. DESCRIPTION

The Contractor shall furnish and install orange flat delineator markers similar to Phase I (tubular marker posts), equipment cabinet decals, and curb/sidewalk markers/medallions with all necessary hardware and adhesives to warn of buried fiber-optic communications cable.

7.2. MATERIALS

(A) Delineator Markers

The Contractor shall furnish delineator markers, also referred to as tubular marker posts, which are approximately 6 feet long and constructed of Type III, high-density polyethylene material. Provide delineator assemblies that are ultraviolet stabilized to help prevent components from color fading, warping, absorbing water, and deterioration with prolonged exposure to the elements. Provide delineators designed to self-erect after being knocked down or pushed over. Provide orange delineator posts.

Provide text, including City contact number, hot stamped in black on a yellow reflective background material that shall not fade or deteriorate over time. Provide delineator markers with nominal message height of 15" that contain the following text visible from all directions approaching the assembly:

W A R N I N G	F I B E R O P T I C C A B L E S
BEFORE EXCAVATING OR IN AN EMERGENCY CALL 703-746-4148	
CITY OF ALEXANDRIA TRAFFIC SIGNAL SYSTEM	

(B) Cabinet Decals

The Contractor shall furnish pressure-sensitive, waterproof decals to apply to the exterior surface of field termination cabinets and cabinets containing CCTV equipment. Construct decals of durable

vinyl or plastic that is chemical resistant and resists tearing and shrinking. Screen print text and symbols on decal using UV-stable, fade-resistant, waterproof ink. Ensure that decal shall adhere permanently to a milled aluminum surface under a variety of weather conditions and a wide range of air temperatures (0° F to 150° F minimum). Provide a decal that can be applied without special surface preparation.

Provide cabinet decals that contain the text and symbols, text emphasis and text proportions depicted in the following examples format:



Overall Decal Dimensions:

6"(w) x 4"(h) minimum,

7"(w) x 5"(h) maximum

Text Height (min.):

1/2" for *WARNING*

3/8" for *BURIED FIBER-OPTIC*

CABLE and *CALL*, 1/2" for *811*

1/4" for all other

Background Color: Yellow

Text Color: Black

Symbol Color: Black

Symbol Size: 1.5"- 2" DIA

Submit sample of proposed cabinet decals to the Engineer for approval before installation. In lieu of designing a custom decal, the contractor may submit for the Engineer's approval a stock/standard decal format (i.e., off-the-shelf format) from the decal manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

(C) Curb Markers

The Contractor shall furnish durable, non-reflective curb markers fabricated from UV-resistant, non-metallic materials other than ceramic material, such as polyurethane or high impact polypropylene or other high impact plastic. Provide curb markers that are designed for outdoor use, that are waterproof, that resist fading, that are temperature stable and that resist chemical and mechanical abrasion. The Contractor shall furnish curb markers with a quick-setting adhesive to permanently adhere curb markers to Portland cement concrete, brick, and granite as well as other non-porous hard surfaces. Do not provide markers that require intrusive fasteners to secure the marker to the surface. Provide curb markers that do not require special tools such as torches, tamping machines or drills or hardware or special surface preparation for installation. The Contractor shall furnish curb markers from a manufacturer that has been producing such curb markers for a minimum of 10 consecutive years. Provide curb markers with a manufacturer's warranty of 10 years or more.

For general marking of underground cable routes in accordance with this Project Special Provision, provide curb markers that contain the text and symbols, text emphasis and text proportions depicted in the following example format:



Overall Curb Marker Dimensions: 2.5" diameter
Text: Black
Background: Orange

Submit samples of proposed curb marker to the Engineer for approval before installation. In lieu of designing a custom curb marker, the Contractor may submit for the Engineer's approval a stock/standard curb marker format (i.e., off-the-shelf format) from the curb marker manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

Have the curb marker manufacturer provide a list of references along with contract information for at least five different municipal government agencies and/or state departments of transportation that have installed the proposed manufacturer's curb marker and can attest to the performance of the manufacturer's curb marker over a continuous period of no less than seven years. Submit these references to the Engineer for review in conjunction with submission of the sample.

7.3. PROCEDURES

(A) Underground Cable Markers in Historic Districts

Obtain the Engineer's approval prior to installing any underground cable markers (i.e., cabinet decals, and curb markers) within historic districts. The Engineer may modify the application criteria described herein or delete the requirement for some or all underground cable markers based upon the requirements of the particular historic district.

(B) Delineator Markers

Submit sample of proposed delineator markers for approval before installation. Install delineator markers using a method that firmly and securely anchors delineator marker in the ground to prohibit twisting and easy removal.

Install delineator markers at locations between junction box locations at 500 foot intervals where conduit is under non-paved areas of Van Dorn St. and Duke St.

At the direction of the Engineer, the Contractor shall furnish only, up to an additional ten delineator markers to replace damaged/missing delineator markers.

(C) Cabinet Decals

Clean the surface to which the decal will be applied using a mild cleaner that will not damage, deface or discolor the milled aluminum finish of the equipment cabinet. The Contractor shall ensure surface is thoroughly dry before applying decal. Observe any application temperature restrictions specified by the manufacturer when applying the decals.

Apply decal to the two sides of the cabinet and not to the front or rear of the cabinets. Do not apply to cabinet doors or over any cabinet vents/louvers. Place the decals in the top right corner. Apply decals to cabinet where fiber-optic cable is routed to and/or from the cabinet in an underground conduit run.

(D) Curb Markers

Install curb markers along curbed streets where the presence of underground fiber-optic communications cable cannot be marked otherwise by placing delineator marker. Examples could include but are not limited to: streetscaped areas, residential neighborhoods, areas without utility poles and downtown areas.

Install the curb markers at the beginning and end of the underground run, at the beginning, and end of each street block along the underground run, at the midpoint of each street block that is approximately 200-500 feet long, and at intervals of approximately 200 feet elsewhere along the underground run. Premark the proposed locations of the curb markers with 2" x 3" wire flags and obtain the Engineer's approval of the proposed locations prior to installing the curb markers. Remove wire flags immediately following installation and acceptance of curb markers. Do not install any curb markers without the Engineer's prior approval.

Clean surface to which the curb marker will be applied. Make sure application surface is flat, dry, and free of any loose debris or cracks. Apply adhesive to back side of curb marker in accordance with manufacturer's instructions. When installing on curb, position marker on top of curb, not on the face of the curb, and center the marker on the top of the curb. Align the curb marker so that arrows (if any) are parallel to the underground cable run and so that text can be read from the adjacent street. Apply the curb marker to the application surface and press firmly. The Contractor shall ensure that entire edge around perimeter of marker is sealed to the application surface.

If the underground conduit runs and associated junction boxes are within 10 feet of the adjacent curb and junction boxes are visible from the curb (e.g., in sidewalk, between curb and sidewalk, at back of sidewalk, etc.), then install the curb markers on the lids of each junction box in lieu of installing them on the curb unless directed otherwise by the Engineer. Where the junction boxes are greater than 10 feet from the curb, install curb markers on the lids of each junction box in addition to installing them on the curb unless directed otherwise by the Engineer.

Where there is no curb and there are no poles on which to install pole tags or decals to mark the underground run, install curb markers on the lids of each junction box.

At the direction of the Engineer, the contractor shall furnish only, up to an additional sixty curb markers complete with quick-setting adhesive.

7.4. MEASUREMENT AND PAYMENT

Delineator marker will be measured and paid for as the actual number of delineator markers (tubular marker posts) furnished, installed, and accepted.

No measurement will be made for cabinet decals and curb markers as they will be considered incidental to furnishing and installing underground conduit.

Payment will be made under:

Pay Item	Pay Unit
Delineator Marker	Each
Furnish only curb markers	Each
Furnish only delineator markers	Each

8. ELECTRICAL SERVICE

8.1. DESCRIPTION

At locations called out in the Plans, modify an existing electrical service, including an external disconnect and meter.

Comply with the National Electrical Code (NEC), the National Electrical Safety Code (NESC), the *Standard Specifications*, these Project Special Provisions, and all local ordinances. Coordinate all work involving electrical service with the appropriate utility company and the

Engineer.

8.2. MATERIALS

The Contractor shall furnish materials in accordance with Section 238 of the *Road and Bridge Specifications*.

Furnish 3-wire stranded copper feeder conductors with THWN rating for supplying power to the termination cabinet. Provide conductors with black, white, and green insulation that are intended for power circuits at 600 V or less and comply with the following:

- Listed as meeting UL Standard UL-83
- Meets ASTM B-3 and B-8 or B-787 standards.

8.3. PROCEDURES

The Phase II Contractor shall perform work in accordance with FHWA Utility Relocations requirements, VDOT Utility Manual of Instruction, and with all standards and requirements of Dominion Power.

Conform to construction methods shown in Standard Drawing 1301.34 of the *Road and Bridge Standards*.

All work involving electrical service shall be coordinated with Dominion Power. Coordinate with Dominion Power to ascertain the feasibility of modifying existing electrical service before performing any work. Obtain all required local permits before beginning work. The Contractor shall bear the cost of obtaining permits.

Install a new 15A breaker for termination cabinet service in a spare slot in the existing disconnect for a traffic signal controller cabinet to enable the termination cabinet to share electrical service with the adjacent traffic signal. Extend electrical service to the termination cabinet by routing new feeder conductors to the termination cabinet through new 1" rigid galvanized conduit as shown in the Plans. Permanently label the circuit breakers to identify which circuit serves the signal controller cabinet and which circuit serves the termination cabinet.

Upon completion of electrical service installation and backfilling of all excavations, restore the disturbed ground to its original condition as determined and approved by the Engineer. For paved areas, replace removed or damaged pavement with in kind materials, matching the elevation, color,

texture/finish, and general appearance of the surrounding pavement. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1½ inches. Finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. Seed with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

Complete repairs to and restoration of all ground (paved and unpaved) disturbed for construction within five consecutive calendar days following initial removal. If the Contractor fails to repair and restore the ground in accordance with these Project Special Provisions within the time frame specified, the City reserves the right to make the necessary repairs, and all expenses incurred by the City in making the repairs and restoring the ground will be deducted from payment due the Contractor, plus \$500 liquidated damages per occasion, per day, or any portion thereof, until corrected.

8.4. MEASUREMENT AND PAYMENT

Modify existing electrical service will be measured and paid for as the actual number of existing electrical service locations that have been modified by installing an additional 15A breaker for shared electrical service to the termination cabinet. No measurement will be made of electrical service feeder conductors, short risers (i.e., from disconnect to underground conduit and from underground conduit to bottom of cabinet), ground wire, and any remaining hardware and conduit to connect the electrical service to the termination cabinet as such work is considered incidental to modifying an existing electrical service.

No measurement will be made of restoration of paved and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will be considered incidental to modifying an existing electrical service. The City will make no payment for a given modify existing electrical service until all repairs to paved and unpaved surfaces damaged/disturbed during the installation the electrical service have been completed and accepted. The City will make no payment for required permits.

Payment will be made under:

Pay Item	Pay Unit
Modify Existing Electrical Service	Each

9. HYBRID CAMERA CABLE

9.1. DESCRIPTION

The Contractor shall furnish and install a composite hybrid cable supplied by the camera vendor consisting of a Category 5e Ethernet cable with a separate 6 conductor 14 AWG power cable combined in a UV Carbon Black LLDPE jacketed cable.

9.2. MATERIALS

(A) Technical Data

Cat 5 E 350 MHZ 24 AWG C11000 ETP Copper
PoE+ –IEEE 802.3at Type-1 15.4 watts @ 48vdc and Type-2 51 watts
Jacket PVC- CMR: Flame Retardant PVC - CMP FR, low Smoke PVC

Power:

Conductor:	6 - 14 AWG C11000 ETP Copper
Shield:	Aluminum / Mylar
Drain Wire	20 AWG 7 STR. TC
Overall Jacket:	UV Carbon Black LLDPE

Product Standard Certification:

- Meets or exceeds:
- CMR/CMX Compliance
- UL 444/ UL 1581 Sunlight Resistant
- CSA C22.2 No. 214-08
- UL 1666
- ANSI/TIA-568-C.2/ICEA SS-90-661-2012
- ISO/IEC 11801
- NFPA 262
- RoHS Compliant
- Environmental -40° C to +75° C

(B) Connectors

RJ-45 connectors with gold-plated contacts shall be provided and terminated according EIA/TIA-568-B standard. Connectors provided shall have eight contacts. The Contractor shall furnish connectors appropriate rated for the cable being installed.

9.3. PROCEDURES

(A) General

The Contractor shall install the Hybrid Camera Cable continuous, without splices, for all locations, including traffic signal controller cabinets, traffic signal poles, traffic signal mast arms, and in conduits or on messenger cable routing the cable from the CCTV camera to the traffic signal cabinet.

The Contractor shall furnish all tools, equipment, materials, supplies, and hardware necessary to install a fully operational Hybrid Camera Cable system as depicted in the Plans. Installation of the Hybrid Camera Cable shall be according to the latest version of the manufacturer's cable installation

procedures and the industry accepted installation standards, codes, and practices, or as directed by the Engineer.

The Contractor shall take all precautions necessary to ensure the Hybrid Camera Cable is not damaged during storage and installation. Contractor personnel shall not step on the cable nor run over the cable with vehicles or equipment. Cable shall not be pulled over or around obstructions or along the ground.

The Contractor shall immediately cease work and notify the Engineer and the affected owner should damage to existing cables or equipment occur. The Contractor shall make the required repairs at no additional cost to the City.

Hybrid Camera Cable shall be installed in continuous lengths with no splices from the camera to the traffic signal cabinet.

In terminating the Ethernet cable of the Hybrid camera cable, the Contractor shall prepare cables to minimize coils of spare cable at the CCTV camera. Contractor personnel shall cut outer Ethernet cable jacket and trim conductors per manufacturer's recommendations. The Contractor shall ensure each conductor extends to the end of the RJ-45 connector before crimping to ensure a solid electrical contact with the gold connectors. Crimp the RJ-45 connector body to lock conductors in channels. Verify the proper termination of the RJ-45 connector using a network cable test analyzer. Document proper TIA-568B termination.

(B) Underground Installation

The Contractor shall install underground Hybrid Camera Cable as shown in the Plans using cable-pulling lubricants approved by the Hybrid Camera Cable manufacturer and the Engineer. The Contractor shall obtain the Engineer's approval of the cable lubricant and method of pulling before the installation of underground Hybrid Camera Cable.

The Contractor shall not exceed 80 percent of the manufacturer's maximum pulling tension when installing underground Hybrid Camera Cable.

The Contractor shall use a clutch device (dynamometer) so as not to exceed the allowable pulling tension if the cable is pulled by mechanical means. The Contractor shall not use a motorized vehicle to generate cable-pulling forces.

The Contractor shall keep tension on the cable reel and the pulling line at the start of each pull. The Contractor shall not release the tension in the cable if the pulling operation is halted. Restart the pulling operation by gradually increasing the tension until the cable is in motion.

The Contractor shall set cable reels up on the same side of the junction box as the conduit section in which the cable is to be installed. The Contractor shall place the reel level and align the reel with the conduit section such that the cable shall pass from the top of the reel in a smooth bend into the conduit without twisting. The Contractor shall not pull the cable from the bottom of the reel and shall manually feed the cable by rotating the reel. The Contractor shall not pull the cable through intermediate junction boxes, pull boxes, hand holes, or openings in conduit unless otherwise approved by the Engineer.

9.4. MEASUREMENT AND PAYMENT

Hybrid Camera Cable will be measured and paid as the actual linear feet of Hybrid Camera Cable furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. No measurement will be made of connectors as such work is considered incidental to installing the Hybrid Camera Cable.

No measurement will be made for short Ethernet cable patch cords that connect adjacent devices/equipment (e.g., between an edge switch and a controller housed in the same cabinet; between equipment housed in the same or adjacent equipment racks in the TMC; between a computer or server and a wall receptacle). Patch cords will be considered incidental to furnishing and installing the equipment that they connect.

Payment will be made under:

Pay Item	Pay Unit
Hybrid Camera Cable	Linear Foot

10. MODIFY CABINET FOUNDATIONS

10.1. DESCRIPTION

Where approved by the Engineer, install conduit entrances into existing foundations in accordance with the Plans and Project Special Provisions. In the plans, this may be shown as “core drill existing cabinet foundation”.

Modify existing foundations in accordance with the Plans and Project Special Provisions.

10.2. MATERIALS

Comply with the Underground Conduit section of these Project Special Provisions.

10.3. CONSTRUCTION METHODS

Install conduit entrances into existing cabinet foundations by core drilling foundations to install additional conduit. The Contractor shall ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

Maintain a minimum of 3 inches of cover between new conduit and edge of foundation. Maintain minimum clearances of 1 inch from the flange of the base adapter and 2 inches from existing conduits. Avoid damaging existing conduit, conductors, and anchor bolts. Repair all such damages. The Contractor shall protect cabinet electronic equipment from dust and water during core drilling operation. Where approved by the Engineer, the foundation may be chipped instead of drilled for conduit entrance. When possible, maintain traffic signal operations while drilling is performed.

Bond new metallic conduit to the cabinet grounding system.

After installation of conduit, place grout to seal around conduit, and return the foundation to normal appearance.

10.4. MEASUREMENT AND PAYMENT

Conduit entrance into existing foundation will be measured as the actual number of conduit entrances drilled into existing cabinet foundations furnished, installed, and accepted.

No measurement or payment will be made for restoration of the surrounding unpaved ground surfaces in accordance with these Project Special Provisions as such work will be considered incidental to the pay items above.

Payment will be made under:

Pay Item	Pay Unit
Conduit Entrance into Existing Foundation	Each

11. CCTV FIELD EQUIPMENT

11.1. MATERIALS

The Contractor shall furnish and install CCTV field equipment and local camera control software described in this Section.

The furnished and installed CCTV camera assembly shall be compatible with the existing CCTV system. The camera shall be the Bosch (Autodome 7000 series).

The Contractor shall provide a surge suppressor with multiple outlets to provide conditioned line side power to the CCTV and Ethernet power supplies.

The Contractor shall provide a system to protect field devices and electronic equipment from lightning and surge protection using UL listed surge protection devices.

11.2. MATERIALS

(A) General

Each CCTV camera assembly shall consist of the following:

- NEMA environmental dome enclosure,
- CCTV color digital signal processing camera unit with zoom lens, filter, control circuit, and accessories,
- On-board digital encoder
- Motorized pan, tilt, and zoom,
- Pole-mount camera attachment hardware,
- All necessary cable, connectors and incidental hardware to make a complete and operable system,
- NEMA Type 4, IP 66 enclosure constructed of aluminum with a clear acrylic dome or approved equal camera unit housing,
- Category 5e Ethernet cable for video and data transmission sized as per the Plans, and
- Surge protection devices.

Each signal cabinet containing CCTV-associated equipment shall consist of the following:

- Power Supply,
- Transient voltage surge suppressors, and
- All necessary cable, connectors and incidental hardware to make a complete and operable system.

The Contractor shall provide camera software as described herein.

(B) Standards

- ASTM,
- CE, Class B,
- FCC Rules Part 15, Sub-part B, Class B

- IEEE,
- ISO 4892-2,
- NEMA 250 4X
- UL Listed.

The Contractor shall provide UL listed surge protection devices according to the UL 1449, 3rd edition standard.

The Contractor shall provide a means to ground all equipment as called for in the *Road and Bridge Specifications*, these Project Special Provisions, and the Plans.

(C) Camera Assemblies

(1) Cameras

The Contractor shall provide new 1/2.8 in. CMOS imager device progressive scan cameras with onboard digital encoder. The camera shall meet the following minimum requirements:

- Resolution: 1080p,
- Manual shutter time
- Guard tour
- Control queue
- On-screen directional indicator
- Processor/Memory: ARTPEC-3, 128 Mb RAM, 128 Mb Flash,
- Local Storage: SD/SDHC memory card slot,
- Camera power: 24 volts AC, max 60W
- Supported Network Protocols IPv4, IPv6, UDP, TCP, HTTP, HTTPS, RTP/RTCP, IGMP V2/V3, ICMP, ICMPv6, RTSP, FTP, ARP, DHCP, APIPA (Auto-IP, link local address), NTP (SNTP), SNMP (V1, V3, MIB-II), 802.1x, DNS, DNSv6, DDNS (DynDNS.org, selfHOST.de, no-ip.com), SMTP, iSCSI, UPnP (SSDP), DiffServ (QoS), LLDP, SOAP, Dropbox™, CHAP, digest authentication
- Protocol Support: Bosch (OSRD), ONVIF, NTCIP
- Streaming Capabilities: Four (4) streams: Two (2) configurable streams in H.264 or H.265; One (1) I-frames only stream based on first stream; One (1) MJPEG Stream
- High dynamic range: 120 dB WDR
- Interoperability: ONVIF Profile S, ONVIF Profile G, ONVIF Profile T, Auto-MDIX
- Custom logo: File format: .bmp; 8 bit (256 colors), 128x128 pixels maximum

(2) Lens

Each camera shall be equipped with a motorized zoom lens with automatic iris control with manual override and neutral density spot filter. Provide lenses that shall meet the following optical specifications:

- Automatic focus: Automatic with manual override,
- Horizontal angle of view: 2.3° to 64.7°,
- Focal length: 30x motorized Zoom (20X optical, 10X digital)
4.3 mm to 129 mm
F1.6 to F4.7
- Shutter time: 1 to 1/10000sec
- Min. illumination at 30 IRE: 0.0077 lux at F1.6 color, 0.0008 lux at F1.6 monochrome

The lens shall be capable of both automatic and remote manual control iris and focus override operation. The lens shall be equipped for remote control of zoom and focus, including automatic movement to any of the preset zoom and focus positions. The unit shall provide mechanical or electrical means to protect the motors from overrunning in extreme positions. The operating voltages of the lens shall be compatible with the outputs of the camera control.

(3) Video Encoding

The selected unit shall provide digital encoding that meets the following specifications:

- Video compression: H.265, H.264, M-JPEG
- Frame rate: 1080p: 30fps; 720p: 60fps

(4) Pan and Tilt Unit

Each new dome style assembly shall be equipped with a pan and tilt unit. The pan and tilt unit shall be integral to dome system. The pan and tilt unit shall be rated for outdoor operation, shall provide dynamic braking for instantaneous stopping, prevent drift, and shall have minimum backlash. The dome shall have an auto flip dome rotation to rotate and reposition camera for viewing objects passing below camera. The unit shall provide electronic image stabilization. The pan and tilt units shall meet or exceed the following specifications:

- Pan: Continuous 360 degrees,
- Tilt: 18 degrees above horizon,
- Presets: 256 Pre-positions, each with 20 characters per title,
- Preset pan speed: 400 degrees/second,
- Preset tilt speed: 300 degrees/second,
- Privacy Masks 32 individually configurable Privacy Masks;
maximum 8 per Pre-position; programmable
with 3, 4 or 5 corners; selectable color of Black,
White, Gray, "Auto" (average background color)

(5) Power Supply

The Contractor shall provide a camera power supply recommended by the manufacturer for the use with the camera.

(6) Control Receiver/Driver

Each new camera unit shall contain a control receiver/driver that shall be integral to the CCTV dome assembly. The control receiver/driver shall receive serial asynchronous data initiated from a camera control unit, decode the command data, perform error checking, and shall drive the pan/tilt unit, camera controls, and motorized lens. As a minimum, the control receiver/drivers shall provide the following functions:

- Zoom in/out,
- Automatic focus with manual override,
- Tilt up/down,
- Automatic iris with manual override,
- Pan right/left, and
- Minimum of 100 preset positions for pan, tilt, and zoom.

In addition, each control receiver/driver shall accept status information from pan/tilt unit and motorized lens for preset positioning of those components. The control receiver/driver shall relay pan, tilt, zoom, and focus positions from the field to remote camera control units. The control receiver/driver shall accept “go to” preset commands from the camera control unit, decode the command data, perform error checking, and drive the pan/tilt and motorized zoom lens to the correct preset position. The preset commands from the camera control unit shall consist of unique values for the desired pan, tilt, zoom, and focus positions.

(7) Camera Housing

The Contractor shall provide new dome style enclosure for assemblies with a high performance integrated dome system or approved equal. The dome housing shall be provided with a 1½” NPT threaded cable entry. Each camera housing shall be equipped with a mounting assembly for attachment to the traffic signal pole or mast arm. The enclosures shall be equipped with a strip heater and a sunshield.

A dome-type environmental housing shall have a sustained ambient operating temperature of 40 degrees F to 131 degrees F, with 100 percent non-condensing relative humidity as defined within the NEMA TS-2 (1998) standard.

The enclosure shall have a NEMA 4X/IP-66 rating.

(D) Camera Mounting Bracket

The Contractor shall provide a pole attachment assembly for the CCTV camera unit to mount on steel poles. The attachment assembly shall use stainless steel banding around the pole and is approved by the Engineer. The Contractor shall submit shop drawings for review and approval by the Engineer prior to delivery.

The Contractor shall provide the CCTV attachment assembly that allows for the removal and replacement of the CCTV enclosure as well as providing a weatherproof, weather-tight, seal that does not allow moisture to enter the enclosure.

A CCTV camera attachment assembly shall be provided that is able to withstand wind loading at the maximum wind speed and gust factor called for in the interim revision of the 2002 ASHTO Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals and which shall support a minimum camera unit dead load of 45 pounds.

(1) Surge Suppression

The Contractor shall supply line side surge protection as recommended by the CCTV supplier. Line side surge protector shall have receptacle outlets sufficient to power both camera and Ethernet switch.

Grounding

The Contractor shall bond the camera bracket to the steel signal pole to ensure connection to the existing grounding system. Incorporate a means to bond (i.e., connected) all metal components of the camera to the grounding system with a grounding cable that shall use a mechanical connection on the equipment side and shall use an exothermic welded connection at the down cable.

(E) Grounding

The Contractor shall test the existing traffic signal grounding system to ensure a resistance of 20 Ω or less according to UL requirements as detailed in the UL 467J standard. If the existing grounding system fails, the Contractor shall add grounding electrodes as described in this section of these Project Special Provisions.

(F) Electrical Power

The CCTV cameras shall be powered by 24V AC power conductors separate from the Category 5e Ethernet cable. The Contractor shall use the separate power cable within the Hybrid Camera Cable. Wiring to comply with Project Construction Plans.

(G) Software

Provide a vendor-supplied GUI-based software that shall allow for setup, configure and operation the cameras in the field. This software shall include features to set communications addresses and protocols, define camera ID lens control, digital signal processing (DSP) settings, azimuth configuration, presets, tours, and privacy zones. The software shall allow the user to control all functions of the camera locally from the traffic signal cabinet at the base of the traffic signal pole with a serial or USB cable.

11.3. PROCEDURES

(A) Electrical and Mechanical Requirements

The Contractor shall ground all equipment as called for in the *Road and Bridge Specifications*, these Project Special Provisions, and the Plans.

(B) CCTV Camera Assembly

The CCTV camera units shall be mounted on traffic signal poles at the attachment heights or locations on traffic signal mast arms, as shown in the Plans. CCTV cameras shall be mounted on the side of pole that is nearest to the intended field of view, to avoid occlusion of the view by the pole or utility lines. The Contractor shall obtain approval of camera orientation from the Engineer. The home position

of a mast arm mounted camera (the hinge of the pipe mount bracket) shall align with the main street field of view approved by the Engineer.

(C) CCTV Camera Attachment to Pole

The Contractor shall have the Engineer approve the CCTV camera location prior to installing the camera on an existing pole. At locations shown in the Plans, the Contractor shall assemble the camera attachment hardware for the CCTV camera unit and attach to the pole using stainless steel banding approved by the Engineer. The Contractor shall submit shop drawings for review and approval by the Engineer prior to installation.

The Contractor shall install the camera attachment assembly to the pole in a manner that shall allow for the removal and replacement of the CCTV enclosure as well as providing a weatherproof, weather-tight seal that does not allow moisture to enter the enclosure.

The CCTV camera attachment assembly shall be provided that is able to withstand wind loading at the maximum wind speed and gust factor called for in the *AASHTO Road and Bridge Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, 6th Edition, 2013 Interim, and shall support a minimum camera unit dead load of 45 pounds.

(D) Traffic Signal Cabinets Housing CCTV Equipment

Ground all cabinets in accordance with the requirements of these Project Special Provisions. Keep the ground wire from the cabinet ground bus bar to the ground rod assembly or array as short as possible. The Contractor shall ensure the ground wire is not in contact with any other part of the cabinet.

Tag and identify all CCTV wiring installed by the Contractor by the use of insulated pre-printed sleeves. The wire markers shall identify in plain words with sufficient details without abbreviations or codes.

Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid sharp edges and to avoid conflicts with other equipment or cabling. Terminate all wiring on a terminal block, strip, bus bar, device clamp, lug, or connector, do not splice any wiring. Label all wiring, cables, terminal strips, and distribution blocks installed by the Contractor. Provide strain relief for all cabling with connectors, all cabling entering knockouts or ports at the equipment, and where appropriate.

Fasten all components installed by the Contractor to be mounted on cabinet side panels with hex-head or Phillips-head machine screws. Install the screws into tapped and threaded holes in the panels. The components include, but are not limited to, terminal blocks; bus bars, and AC low power supply chassis.

Connect the Ethernet edge switch to the CCTV camera assembly using the Category 5e Ethernet cable of the hybrid camera cable.

Connect both 24V AC power sources, camera power and heater power, to the CCTV camera assembly using power conductors of the hybrid camera cable.

Install the Ethernet edge switch inside the signal cabinet in accordance with the “Communications Hardware” section of these Project Special Provisions. Mount the edge switch on a DIN rail securely fastened to the side or rear backplate of the traffic signal cabinet as indicated in the plans. If no backplate

is available, the contractor shall provide and install such backplate to securely fasten the DIN rail for the mounting of the Ethernet switch and switch power supply. Connect the appropriate connectors on the drop cable assembly patch panel with those on the Ethernet edge switch using LC-UPC to LC-UPC SMFO jumpers.

(1) Power Service

Plug Ethernet edge switch and power supply into multiple outlet surge suppressor.

(E) Grounding

The Contractor shall test the existing traffic signal grounding system to ensure a resistance of 20 Ω or less according to UL requirements as detailed in the UL 467J standard. If the existing grounding system fails, the Contractor shall add grounding electrodes as described in this section of these Project Special Provisions until a resistance of 20 Ω or less is achieved. The contractor shall follow the CCTV Supplier recommended procedure to properly ground and bond the CCTV camera to validate camera warranty requirements. The Contractor shall ensure the CCTV camera is bonded to the pole. The Contractor shall connect pole's grounding provision mechanically to a #6 grounding electrode conductor (GEC) and corrosion inhibitor. The Contractor shall make sure that #6 GEC is exothermically welded to a new 10 foot long, 3/4" dia. copper or copper-clad ground rod installed in the nearest pull box adjacent to the camera pole. The Contractor shall use an additional #6 GEC which is exothermically welded to the ground rod in the camera pole's pull box and install it to the pull box adjacent to the controller cabinet and exothermically weld it to a new 10 foot long, 3/4" dia. copper or copper-clad ground rod installed in that pull box. The Contractor shall use an additional #6 GEC which is exothermically welded to the ground rod in the pull box adjacent to the controller cabinet and install and connect to the traffic cabinet equipment ground buss. The Contractor shall make sure that the CCTV system is properly grounded and bonded.

Connect all grounding points related to CCTV pole and its subsystems to a single point main grounding electrode, sometimes referred to as the ground window, which shall be driven a minimum of 12 inches from the CCTV pole. Each grounding electrode requires an interfacing hemisphere, an imaginary cylinder with a diameter and depth equal to the length of the electrode. Therefore, a grounding electrode that is a minimum of 10 feet long shall be installed 10-20 feet away from any additional grounding electrodes and/or ground-mounted devices.

Install a minimum of one grounding radiant, plus additional radiants as required to achieve a resistance to ground of 20 Ω or less, at each CCTV pole. This grounding radiant shall consist of one main 3/4" copper or copper clad steel grounding rod that is a minimum of 10 feet long located at the structural base of the CCTV pole and attached to one additional 20-foot radiant grounding rod placed a minimum of 20 feet away from the main grounding rod. Attach the main grounding rod to the CCTV pole by a solid #6 ground cable that shall be exothermically welded. Attach the radiant grounding rod to the main grounding rod with a minimum #6 solid bare copper wire that is exothermically welded at both the main grounding rod and the radiant grounding rod.

(1) Device Line Side

The multiple outlet surge protection device shall be wired directly to the backboard of the traffic control cabinet under the direction of the Engineer to provide power to the line side of the CCTV and Ethernet switch power supplies. This device shall provide protection between line-to-neutral, line-to-ground, line-to-line and neutral-to-ground.

(F) Software

Install the vendor-supplied GUI-based software to setup, configure and operate the cameras on each laptop.

(G) GPS Coordinates

Provide real world coordinates for all junction boxes and equipment cabinets installed or utilized under this project in accordance with the *VDOT Geo-Spatial Data Delivery Recommendations*. The Contractor shall furnish coordinates that do not deviate more than 1.7 feet in the horizontal plane and 3.3 feet in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, City system ID number) in the Microsoft Excel spreadsheet using the format shown in example below.

City System ID#	Name	Location	Latitude	Longitude	Manufacturer	Model #
	Equipment Cabinet	Elm St. at Oak Rd.	-78.5500	35.6873	McCain	Type-336S
	Junction Box # 1 (Phase 2 Side)	Elm St. at Oak Rd.	-78.5516	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 2 (Phase 2 Side)	Elm St. at Oak Rd.	-78.5506	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 3 (Near Cabinet)	Elm St. at Oak Rd.	-78.5501	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 4 (Phase 6 Side)	Elm St. at Oak Rd.	-78.5486	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 5 (Phase 6 Side)	Elm St. at Oak Rd.	-78.5493	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
	Junction Box # 6 (Phase 5 Side)	Elm St. at Oak Rd.	-78.5503	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)

(H) Testing and Acceptance

The Contractor shall comply with the CCTV testing requirements as defined in Section 19.3 of these Project Special Provisions.

The Engineer shall make a determination of acceptance following inspection of the CCTV field equipment installations and review of the installed site test results of the CCTV field equipment.

For Furnished CCTV Camera assemblies, the Contractor shall utilize a test stand to comply with the CCTV testing requirements as defined in Section 19.2 of these Project Special Provisions.

The Engineer shall make a determination of acceptance of furnished CCTV camera assemblies following inspection of the CCTV camera assemblies and review of the pre-installation field demonstration test results of the CCTV camera assemblies.

11.4. MEASUREMENT AND PAYMENT

CCTV camera assemblies will be measured and paid as the actual number of CCTV camera assemblies furnished, installed, tested, and accepted. A payment of 60 percent will follow installation. The remaining 40 percent will follow testing and acceptance.

No separate measurement will be made for connectors, CCTV camera attachment assemblies, software, ground testing, power supplies, power conductors, surge protector devices, other cabling, and conduit, or any other equipment or labor required to install the CCTV assembly and integrate it with the fiber-optic communications equipment as they are considered incidental to furnishing and installing the CCTV camera assembly.

Furnish CCTV camera assemblies will be measured and paid as the actual number of CCTV camera assemblies furnished, tested and accepted. This item includes connectors, CCTV camera attachment assemblies, software, grounding equipment, surge protector devices, and cabling. A payment of 60 percent will follow delivering. The remaining 40 percent will follow testing and acceptance.

Install grounding system will be measured and paid as the actual number of grounding systems furnished, installed, and accepted. This item includes connectors, rods, cabling, and connectors.

Payment will be made under:

Pay Item	Pay Unit
CCTV Camera Assembly	Each
Furnish CCTV Camera Assembly	Each
Grounding System	Each

12. CCTV SOFTWARE

12.1. DESCRIPTION

Phase III Contractor shall furnish and install a network- ready, client-server CCTV system software package. This software package provides complete command and control of the CCTV cameras as well as distributes video to the TMC monitor wall and over the City’s LAN. The Phase III Contractor shall ensure that Phase III field equipment specified in Sections 5, 6, 9, 11, 12, 13 and 14 of these Project Special Provisions, and furnished and installed as part of Phase III, are fully compatible with Phase I equipment. The Phase III Contractor shall obtain City-approved cut sheets for the installed network-ready, client-server CCTV system software package and shall ensure that Phase III field equipment is fully compatible with the TMC equipment. Expand the Bosch Video Management System licenses to accommodate the addition of the Phase III cameras to the system.

Payment will be made under:

Pay Item	Pay Unit
CCTV Software	Lump Sum

13. COMPUTER HARDWARE AND PERIPHERALS

13.1. DESCRIPTION

Phase III Contractor shall furnish and install ITS servers, computer workstations, a KVM switch, and UPS units in the TMC. The Phase III Contractor shall ensure that Phase III field equipment specified in Sections 5, 6, 9, 11, 12, and 14 of these Project Special Provisions, and furnished and installed as part of Phase III, are fully compatible with Phase I equipment. The Phase III Contractor shall obtain City-approved cut sheets for the installed ITS servers, computer workstations, KVM switch, and UPS units and shall ensure that Phase III field equipment is fully compatible with the TMC equipment.

Contractor shall provide latest version Network Management Server (NMS). Contractor shall transfer existing NMS database with What's Up Gold software to a new NMS server. NMS Server specifications should meet or exceed following server requirements:

Web server requirements

- Processor(s): Quad-core
- Processor speed: 2.6 GHz or more
- RAM: 8 GB
- Database type: SQL Server 2014 Express Edition
- Hard drive: 25 GB or more free space
- Network interface card: Minimum 100 Mbps (1 Gbps preferred)
- Video display resolution: 1280 x 1024 or higher
- Sound card: SAPI-capable sound card required for Text-to-Speech actions
- Modem and phone line: Required for pager, SMS, and beeper actions; modem pooling is not supported
- GSM modem: Required for SMS Direct actions
- OS: IIS version 7.x, 8.x, or 10.0.
- Web Server
- ASP .NET
- Static Content
- HTTP Redirection
- Default Document

Framework and accessibility requirements

- .NET 4.7.2, included in installation program
- PowerShell 2.0
- Microsoft Windows Scripting Host v5.7 (or later)
- Microsoft SAPI 5.1 (required for Text-to-Speech actions)

Web interface requirements

- Microsoft Internet Explorer 11
- Chrome v57
- Firefox 53

Supported virtual environments

VMware vCenter Server versions 4.0, 4.1, 5.0, 5.5, 6.0, and 6.5

- VMware ESX versions 3.5, 4.0, and 4.1
- VMWare ESXi versions 3.5, 4.0, 5.0, 5.1, 5.5, 6.0, and 6.5
- Hyper-V Server 2012
- Hyper-V Server 2012 R2
- Windows Server 2012 (Hyper-V Role enabled)
- Windows Server 2012 R2 (Hyper-V Role enabled)
- Hyper-V 2016 (effective for Service Pack 2)

Network traffic analysis software requirements

- NetFlow versions 1, 5, 7, or 9
- NetFlow-Lite
- Flexible NetFlow
- NetFlow v9 NSEL (NetFlow Secure Event Logging)
- sFlow versions 2 or 5
- J-Flow
- IPFIX

Furnish two laptop computers to the City. The laptop computers shall be compatible with TMC equipment. Furnish laptop computers with the most recently developed and approved product versions that meet or exceed all applicable standards, specifications, and requirements before the system is considered for acceptance. Ensure that all equipment features, functions, and performance measures are provided or met. Furnish new products obtained from the manufacturer or reseller. Provide commercial off the shelf materials, equipment, and components.

Furnish laptop computers or approved equal consisting of a CPU, monitor, keyboard, and mouse.

13.2. MATERIALS

(1) Functional

Laptop computers shall be able to operate the video control software over an Ethernet network in TMC.

(2) Performance

The Contractor shall ensure that the laptop computers shall meet the following minimum requirements. Laptops shall have the capability to be networked with the ITS LAN via a Fast Ethernet cable connection through a Gigabit Ethernet core switch located in the TMC and over the Internet. The laptop computers shall be configured for connection anywhere in the network to facilitate maintenance and troubleshooting activities. Provide laptops meeting the following minimum requirements:

Processor:	7th Generation Intel® Core™ i9-9980HK (16 MB Cache, 8 Core, up to 5 GHz),
Memory:	64GB DDR4-2666MHz, 2x32G,
Network:	Killer Wi-Fi 6 AX1650 (2x2) and Bluetooth 5.0,
Primary Battery:	6-Cell, 97 WHr, Integrated battery,
Hard Drive:	1TB M.2 PCIe NVMe SSD,
Graphics Card:	NVIDIA® GeForce® GTX 1650 4GB GDDR
Keyboard:	104 key model,
Mouse:	Two (2) wireless, three-button optical mice,
Audio:	Miniature phono jacks – line out, line in, and microphone
Sound:	Integrated audio with built-in speakers,
Video Card:	2GB GDDR3,
Internal Monitor:	15.6" 4K UHD (3840 x 2160) OLED InfinityEdge Anti-Reflective Non-Touch 100% DCI-P3 400-Nits display,
Operating System:	Windows 10 Pro, 64-bit, English,
Port and Slots	SD card slot, USB 3.1 Gen 1, Battery gauge button and indicator, Wedge-shaped lock slot, AC power, USB 3.1 Gen 1, HDMI 2.0, Thunderbolt™ 3 (4 lanes of PCI Express Gen 3) supporting: Power Delivery, Thunderbolt™ 3 (40Gbps bi-directional), USB 3.1 Gen 2 (10Gbps), Native DisplayPort 1.2 video output, VGA, HDMI, Ethernet and USB-A via Dell Adapter (sold separately), Headset jack, External DVD drive
Application software:	Windows Office 2019 Professional and enterprise version of McAfee® software compatible with City requirements, and DVD burning software, and
Other Accessories:	Two AC adaptors per laptop, docking station, spare battery and nylon travel bag. External 500GB SSD hard drive for each laptop.

(3) Physical Features

The Contractor shall ensure that the laptop computers operate on an input voltage of 90 to 135 VAC at 50/60 Hz. Laptop computers shall meet the following minimum port requirements:

Parallel:	One parallel port,
Keyboard:	One USB connection,
Mouse:	One USB connection,
Audio:	Three jacks – channel out, line in, and microphone,
Ethernet:	10/100 Base T Ethernet with RJ-45 connector, and

USB Port: Three USB 2.0 ports.

The laptop computers shall be equipped with at least one direct 10/100 Base T Ethernet LAN interface. Ensure that the network connector is an RJ-45 for Category 5e UTP to interface with the Gigabit Ethernet core switch.

13.3. PROCEDURES

The Contractor shall ensure that all project IP addresses are assigned as defined in the System Design Report. The City IT Department has provided the following series of IP addresses:

Network: 10.70.0.0 Subnet: 255.255.0.0

The Contractor shall ensure the as-built documentation includes the identification of all IP addresses and VLANs, and associated hardware devices and device locations.

13.4. DOCUMENTATION

Furnish all software and operating system on CD or DVD with original license information registered to the City of Alexandria.

13.5. WARRANTY

Provide a minimum of one-year manufacturer’s warranty to guarantee the materials supplied are free of defects and workmanship. The manufacturer’s warranty period starts upon the date of final acceptance.

13.6. MEASUREMENT AND PAYMENT

Laptop computer will be measured and paid as the actual number of laptop computers furnished and accepted.

Payment will be made under:	
Pay Item	Pay Unit
Furnish Laptop Computer	Each
Network Management Server and latest version of NMS software	Each

14. COMMUNICATIONS HARDWARE

14.1. DESCRIPTION

Phase I (State project number U000-100-131, P101, C501) furnished and installed a Layer 3 Gigabit Ethernet core switch, firewall, edge switches (fiber), edge switches (copper), Ethernet extenders, UPS, and network management software in the TMC and field. The Phase III Contractor shall ensure that Phase III field equipment specified in Sections 5, 6, 9, 11, 12, and 14 of these Project Special Provisions, and furnished and installed as part of Phase III, are fully compatible with Phase I and II equipment. The Phase III Contractor shall obtain Phase I City-approved cut sheets for the installed Layer 3 Gigabit Ethernet core switch, firewall, edge switches (fiber), edge switches (copper), Ethernet extenders, UPS and network management software, and shall ensure that Phase III field equipment is fully compatible with the Phase I TMC equipment.

The Contractor shall furnish and install or furnish only as noted below all equipment described below for a fully functional Gigabit Ethernet network for communication to the signal system and CCTV.

The Phase III Contractor shall be responsible for updating the network management software (NMS) database with new devices installed in Phase III.

(A) General

The Contractor shall ensure that the Ethernet switches are fully compatible and interoperable with the trunk Ethernet network interface and that the Ethernet switches support half and full duplex Ethernet communications.

The Contractor shall furnish Ethernet switches that provide 99.999% error-free operation, and that complies with the Electronic Industries Alliance (EIA) Ethernet data communication requirements using single-mode fiber-optic transmission medium and copper transmission medium.

(B) Edge Switch

The Contractor shall furnish and install a hardened, managed layer 2 field Ethernet edge switch-fiber (hereafter “edge switch”) for field devices. The Contractor shall ensure that the edge switch provides wire-speed, fast Ethernet connectivity at transmission rates of 10 Gigabits per second from each remote ITS device location to the existing core switch. The Contractor-provided edge switch shall be fully compatible with existing Juniper EX4550 10Gb SFP+ Layer 3 switch used by the City. The edge switch shall be ITS Express (Model ITS 8042, 8042+).

(1) Standards

The edge switch shall comply with all applicable IEEE networking standards for Ethernet communications, including but not limited to:

- IEEE 802.1D standard for media access control (MAC) bridges used with the Spanning Tree Protocol (STP),
- IEEE 802.1Q-2005 standard for port-based virtual local area networks (VLANs), and Multiple Spanning Tree Protocol (MSTP),
- IEEE 802.1P standard for Quality of Service (QoS) with Weighted Random Early Detection (WRED),

- IEEE 802.1w standard for MAC bridges used with the Rapid Spanning Tree Protocol (RSTP),
- IEEE 802.1x standard for port based network access control, including RADIUS,
- IEEE 802.3 standard for local area network (LAN) and metropolitan area network (MAN) access and physical layer specifications,
- IEEE 802.3u supplement standard regarding 100 Base TX/100 Base FX,
- IEEE 802.3x standard regarding flow control with full duplex operation,
- RFC 783 – TFTP,
- RFC 854 – Telnet Protocol Specification,
- RFC 1112 – IGMP v1,
- RFC 1541 – Dynamic Host Configuration Protocol for IPv4,
- RFC 2030 – SNMP,
- RFC 2068 – HTTP,
- RFC 2236 regarding IGMP v2 compliance,
- RFC 2865 – RADIUS,
- RFC 3414 – SNMPv3-USM, and
- RFC 3415 – SNMPv3-VACM.

The edge switch shall have a minimum mean time between failures (MTBF) of 10 years, or 87,600 hours, as calculated using the Bellcore/Telcordia SR-332 standard for reliability prediction.

(2) Functional

The edge switch shall support all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing. These features shall include, but not be limited to:

- An STP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1D standard,
- An RSTP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1w standard,
- An Ethernet edge switch that is a port-based VLAN and supports VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard, and has a minimum 4-kilobit VLAN address table (254 simultaneous),
- A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second and 148,800 packets per second for 100 megabits per second,
- A minimum 4-kilobit MAC address table,
- Support of Traffic Class Expediting and Dynamic Multicast Filtering,
- Support of, at a minimum, snooping of Version 2 of the Internet Group Management Protocol (IGMP),
- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces,

- Support of the Simple Network Management Protocol version 3 (SNMPv3). Verify that the Ethernet edge switch can be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP),
- Port security through controlling access by the users. Ensure that the Ethernet edge which has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network,
- Support of remote monitoring (RMON-I) of the Ethernet agent, and
- Support of the TFTP and SFTP. Ensure that the Ethernet edge switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

(3) Physical Features

Mounting: The Contractor shall provide DIN-railmount edge switches.

Ports: The edge switch shall provide 10/100/1000 Mbps auto-negotiating ports (RJ-45) copper Fast Ethernet ports for all edge switches. The edge switch shall provide auto-negotiation circuitry that shall automatically negotiate the highest possible data rate and duplex operation possible with attached devices supporting the IEEE 802.3 Clause 28 auto-negotiation standard. The edge switch shall provide integrated copper cable testing on all of the copper ports. This testing shall provide cable data including indication of pair transposition, pair shorting, and cable length in the switch web GUI.

Optical Ports: Optical ports shall incorporate Digital Optical Monitoring (DOM) technology whereby real-time operating parameters are provided such as: optical Tx power, optical Rx power, laser bias current, optic temperature, and transceiver supply voltage. When user-defined thresholds for these parameters are met, the edge switch shall be capable of generating SMTP emails or Syslog messages to alert support staff. The Contractor shall ensure that all optical ports utilize the changeable small form factor pluggable or (SFP/SFP+) optic MSA SFF Committee INF-8074i specifications, supporting multimode and/or singlemode transceivers.

The edge switch shall have a minimum of four optical ports consisting of two 100/1000/2.5/10Gb SFP+ ports and two 100/1000/2.5Gb SFP ports capable of transmitting data at 10Gb and 2.5Gb per second, respectively. Each optical port shall consist of a pair of fibers, one fiber shall transmit (TX) data and one fiber shall receive (RX) data. The optical ports shall have an optical power budget of at least 15 dB. All optical ports shall be filled with gigabit interface converters (GBICs) or small form-factor pluggable (SFP) ports that are capable of transmitting data at 100 Mbps and a standard reach (10km).

Provide optical bypass functionality in the edge switch through industry standard LC style fiber optic ports. The optical bypass feature shall be available in-line between cabinet fiber optic connection panels and the edge switch optical ports such that fiber optic connectivity can be dynamically rerouted between panel-to-switch connections and panel-to-panel connection based on cabinet power status, or more specifically, edge switch power status.

Copper Ports: The edge switch shall include a minimum of four copper ports. The edge switch shall provide Type RJ-45 copper ports and that auto-negotiate speed (i.e., 10/100 Base) and duplex (i.e., full or half). All 10/100 Base TX ports shall meet the specifications detailed in this section and are compliant with the IEEE 802.3 standard pinouts. All Category 5e unshielded twisted pair/shielded twisted pair network cables shall be compliant with the EIA/TIA-568-A standard.

Port Security: The edge switch shall support and shall comply with the following (remotely) minimum requirements:

- Ability to configure static MAC addresses,
- Ability to disable automatic address learning per ports, know hereafter as Secure Port. Secure Ports only forward, and
- Trap and alarm upon any unauthorized MAC address and shutdown for programmable duration. Port shutdown requires administrator to manually reset the port before communications are allowed.

(4) Management Capabilities

The edge switch shall support all Layer 2 management features and certain Layer 3 features related to multicast data transmission and routing. These features shall include, but not be limited to:

- An STP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1 D standards,
- An RSTP healing/convergence rate that meets or exceeds specifications published in the IEEE 802.1w standard,
- An Ethernet edge switch that is a port-based VLAN and supports VLAN tagging that meets or exceeds specifications as published in the IEEE 802.1Q standard, and has a minimum 4-kilobit VLAN address table (254 simultaneous),
- A forwarding/filtering rate that is a minimum of 14,880 packets per second for 10 megabits per second and 148,800 packets per second for 100 megabits per second,
- A minimum 32-kilobit MAC address table,
- Support of Traffic Class Expediting and Dynamic Multicast Filtering,
- Support of, at a minimum, snooping of Version 2 of the Internet Group Management Protocol (IGMP),
- Support of remote and local setup and management via telnet or secure Web-based GUI and command line interfaces, and
- Support of the Simple Network Management Protocol (SNMP). Verify that the Ethernet edge switch can be accessed using the resident EIA-232 management port, a telecommunication network, or the Trivial File Transfer Protocol (TFTP).

Network Capabilities: The edge switch shall support and comply with the following minimum requirements:

- Provide full implementation of IGMPv2 snooping (RFC 2236),
- Provide full implementation of SNMPv1, SNMPv2c, and/or SNMPv3,
- Provide support for the following RMON–I groups, at a minimum,
 - Part 1: Statistics ○ Part 3: Alarm
 - Part 2: History ○ Part 9: Event
- Capable of mirroring any port to any other port within the switch,
- Meet the IEEE 802.1Q (VLAN) standard per port for up to four VLANs,
- Meet the IEEE 802.3ad (Port Trunking) standard for a minimum of two groups of four ports,
- Password manageable,

- Remote access via Telnet & SSHv2,
- HTTP (Embedded Web Server) with Secure Sockets Layer (SSL), and
- Full implementation of RFC 783 (TFTP) to allow remote firmware upgrades.

Network Security: The edge switch shall support and comply with the following (remotely) minimum network security requirements:

- Multi-level user passwords,
- RADIUS centralized password management (IEEE 802.1X),
- SNMPv3 encrypted authentication and access security,
- Port security through controlling access by the users: ensure that the Ethernet edge switch has the capability to generate an alarm and shut down ports when an unauthorized user accesses the network,
- Support of remote monitoring (RMON) of the Ethernet agent, and
- Support of the TFTP and Sntp. Ensure that the Ethernet edge switch supports port mirroring for troubleshooting purposes when combined with a network analyzer.

(5) Electrical Specifications

The edge switch shall operate with power supplied with 115 volts of alternating current (VAC). The edge switch shall have a minimum operating input of 110 VAC and a maximum operating input of 130 VAC. If the device requires operating voltages other than 120 VAC, the Contractor shall supply the required voltage converter. The maximum power consumption shall not exceed 50 watts. The edge switch shall have diagnostic light emitting diodes (LEDs), including link, TX, RX, speed (for Category 5e ports only), and power LEDs.

(6) Environmental Specifications

The edge switch shall perform all of the required functions during and after being subjected to an ambient operating temperature range of -30 degrees to 165 degrees Fahrenheit as defined in the environmental requirements section of the NEMA TS 2 standard, with a non-condensing humidity of 0 to 95%.

The Contractor shall verify that the edge switch manufacturer certifies that their device has successfully completed environmental testing as defined in the environmental requirements section of the NEMA TS 2 standard. Verify that vibration and shock resistance meet the requirements of Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard shall be met. The Contractor shall ensure that the edge switch is protected from rain, dust, corrosive elements, and typical conditions found in a roadside environment. The edge switch shall meet or exceed the following environmental standards:

- IEEE 1613 (electric utility substations),
- IEC 6185003 (electric utility substations),
- IEEE 61800-3 (variable speed drive systems), and
- IEC 61000-6-2 (generic industrial).

14.2. PROCEDURES

(A) General

The Contractor shall ensure that all communications hardware is UL listed.

The Contractor shall verify that network/field/data patch cords meet all ANSI/EIA/TIA requirements for Category 5e and Category 5 four-pair unshielded twisted pair cabling with stranded conductors and RJ-45 connectors.

The Contractor shall receive approval for the System Design Report described in these Project Special Provisions before submitting products submittal data, purchasing, installing and configuring the computer and communications hardware at each facility.

The Contractor shall ensure that all project IP addresses are assigned as defined in the System Design Report. The Contractor shall further ensure the as-built documentation includes the identification of all IP addresses and VLANs, and associated hardware devices and device locations.

(B) Edge Switch

The Contractor shall ensure that the City's TES/Transportation/Traffic Network Engineer (contact Mark Skinger (703) 746-4148) shall be able to manage each edge switch individually or as a group/cluster for switch configuration, performance monitoring, and troubleshooting. Note that these specifications require additional minimum management intelligence (i.e., Layer 2+) typical of most current industrial Ethernet deployments. The Contractor shall ensure that the edge switch includes Layer 2+ capability providing architecture standardization, open connectivity (i.e., interoperability), bandwidth management, rate limiting, security filtering, and general integration management of an advanced Ethernet switching architecture.

Provide optical bypass functionality in the edge switch through industry standard LC style fiber optic ports. The optical bypass feature shall be available in-line between cabinet fiber optic connection panels and the edge switch optical ports such that fiber optic connectivity can be dynamically rerouted between panel-to-switch connections and panel-to-panel connection based on cabinet power status, or more specifically, edge switch power status.

All project IP addresses and VLAN IDs shall be assigned as defined in the System Design Report.

The edge switch shall be mounted inside each field cabinet by securely fastening the edge switch to a DIN rail using manufacturer-recommended or Engineer-approved attachment methods, attachment hardware and fasteners. The Contractor shall ensure that the edge switch is mounted securely in the cabinet and is fully accessible by field technicians without blocking access to other equipment. The Contractor shall verify that fiber-optic jumpers consist of a length of cable that is connectorized on both ends, primarily used for interconnecting termination or patching facilities and/or equipment. Use fiber-optic jumpers that are factory assembled and connectorized and are certified by the fiber-optic jumpers' manufacturer to meet the relevant performance standards required below. Verify that network/field/data jumper cables shall meet all ANSI/EIA/TIA requirements for Category 5e 4-pair unshielded twisted pair cabling with stranded conductors and factory-terminated RJ45 connectors.

14.3. MEASUREMENT AND PAYMENT

The switches shall include all appropriate ports, cabling, grounding, redundancies, labeling, and any integration between the switches and the communications network as necessary to make a fully working installation.

The Contractor shall furnish and install and furnish only materials, all power supplies, power cords, adapters, mounting plate and hardware, DIN rail mounting brackets, DIN rails, connectors, serial cables, signs, decals, disconnect switches, installation materials, and configuration software necessary to complete this work, shall be included and shall be incidental.

Edge switch will be measured and paid as the actual number of Ethernet edge switches furnished, installed, and accepted. The cost of the edge switches shall include the GBICs/SFPs.

Furnish edge switch will be measured and paid as the actual number of Ethernet edge switches furnished and accepted.

No separate measurement will be made for GBICs/SFPs, cables, Ethernet patch cables, electrical cables, mounting hardware, nuts, bolts, brackets, connectors, grounding equipment, surge suppression, updating network management software, or training as these will be considered incidental to the pay items listed above.

Optical Line Terminal (OLT) shall be Calix E-7 Series.

OLT shall consist of:

Calix E-7, 1U, Rack-mountable chassis

Calix GPON-8 interface cards

Calix 48VDC power supply suitable for full system expansion.

Calix SFP Transceiver modules compatible with ONT SFP modules.

Calix interconnecting cables between E-7 chassis.

Optical Network Terminal (ONT) shall be Calix 700 Series.

ONT shall consist of:

Calix 716-GE ONT

Calix 700 ONT Structured wiring enclosure bracket

Calix Splice Tray SFU with SC-APC Adapter

Calix ONT CMN-PS100-240VAC to 12VDC power supply.

Multiple outlet surge protection device shall be installed as per CCTV Specifications for ONT equipment.

Bracket shall be securely fastened in place to the side rails or mounting plate of the controller cabinet.

PON drop cable shall be fastened to bracket. Preterminated PON drop cable can be directly connected to the ONT Input SC-APC Adapter. Unterminated PON drop cable can be terminated with a fusion splicable SC-APC connector or fusion spliced to an SC-APC pigtail in the ONT Splice Tray. The SC-APC connector can then be connected to the ONT Input SC-APC Adapter

A factory-terminated Cat 5e patchcord shall connect ONT Port 1 to the Traffic Controller Ethernet Port. Provisioning and implementation of traffic controller communications must be coordinated through the Traffic Network Engineer, Mark Skinger, 703-746-4148.

Payment will be made under:

Pay Item	Pay Unit
Ethernet Edge Switch	Each
Furnish Edge Switch	Each
ONT Switch	Each
OLT Switch	Each

15. CENTRAL VIDEO EQUIPMENT

15.1. DESCRIPTION

Phase III Contractor shall furnish and install video monitors, monitor cables and related equipment in the TMC. The Phase III Contractor shall ensure that Phase III field equipment specified in Sections 5, 6, 9, 11, 12, and 14 of these Project Special Provisions, and furnished and installed as part of Phase III, are fully compatible with Phase I equipment. The Phase III Contractor shall obtain City-approved cut sheets for the video monitors, monitor cables and related equipment, and shall ensure that Phase III field equipment is fully compatible with the TMC equipment.

15.2. VIDEO WALL PROCESSOR

The existing front video wall system will be upgraded with new 3 H x 5 W displays. The side video wall system will have new 2 H x 2 W displays. Both walls will be composed of 55" LCD video wall displays with a tiled bezel width of 0.88 mm (between displays) to provide a nearly seamless digital canvas. The contractor shall design the video wall system for 24x7 operation. The contractor shall feature the displays to be: a minimum of 500 nits brightness; LED backlight technology; and Full 1080p HD resolution. The contractor shall install the remote power supplies for the video display walls in the adjacent server room.

15.3. PROCEDURE

The contractor shall replace the large white boards on the back wall with two (2) new 98" displays providing a multitouch experience with 4K image clarity. Each display will provide twenty (20) points of multi-touch and multiuser technology enabling multiple users to collaborate and interact at the same time.

The contractor shall provide an (expandable) USB matrix between these two (2) interactive displays and the five (5) existing customer workstations. Any source to either 98" display location (via the control system).

The contractor shall provide video conferencing (for the conference table participants) via a wall mounted camera adjacent to the side video wall displays. This solution shall offer automated speaker-tracking and auto-framing capabilities. The contractor shall have any UHD codec equipment in the server room equipment racks.

The contractor shall provide a wireless presentation solution enabling presentations of full HD video at frame rates of up to 30fps to be viewed wirelessly through the video wall system displays from a personal computer, laptop or mobile device.

The contractor shall provide distributed audio via four (4) full-range flat field in-ceiling speakers with low profile enclosures.

The contractor shall provide two (2) removable tabletop mounted microphone arrays to capture local audience participants at the conference table for video conferencing.

The contractor shall provide audio followed by video and source selection; muting and volume control on the touch panels.

The contractor shall provide dual control touch panels; one (18" minimum) at the operations console station and one (12" minimum) at the conference tabletop. All touch screen programming will be developed so to make it as easy as possible for non-technical staff to operate the equipment.

This upgrade will continue to utilize the existing Bosch Video Management System (BVMS) for the management of the existing Bosch IP cameras. The video transmission to the new video wall displays will be removed from the BVMS solution.

15.4. STANDARD

The Contractor shall include the following specifications in their RFP:

(A) Video Walls

- The video wall must be made up of 55" direct view LCD in an architecture, which include slim LCD modules with an integrated mounting system, off-board electronics and redundant power supplies, and built-in image processing.
- 6-Axis Adjustable Mount: The LCD module must include an integrated mounting system that allows for 6-axis of adjustments to achieve a perfectly aligned LCD array.
- The installed depth of the LCD module must be less than 3.6" (91.4 mm). The install depth must be compliant with the Americans with Disabilities Act (ADA) for protrusion under 4".
- In-Wall Servicing: The LCD module and mounting system must allow for a LCD to be put into a service position to access components or make cable connections from the front of the video wall.
- The LCD module and mounting system must allow the removal of a LCD module without completely taking down the LCD modules around it. The components on the back of the LCD module need to be serviceable from the front of the wall when installed.
- Noise: The display must utilize a fan-less LCD design.
- Operating Temperature: The display must be able to operate in a 5-40°C (41-104°F) environment.
- Operating Humidity: The display must be able to operate in a 20-90% RH non-condensing environment.
- Mounted Depth (wall to display front): 91.4mm (3.6in)
- LCD Technology: Commercial-grade direct view LCD
- Display Resolution: 1920 x 1080
- Contrast Ratio: 10000:1 local dimming on, 1100:1 local dimming off
- Full Viewing Angle: 178°
- Backlight Sensing and Reporting: At display level
- Display Module Position Sensing: Auto-sensing integrated
- Redundancy: n + 1 redundant option
- Power supply voltage: 100-240V AC \pm 10%, 50 to 60 Hz
- Controller status: Diagnostics LEDs, health monitoring and alerts
- Acoustic Noise: Fanless operation at the display

- Operating Temperature/Humidity (degrees F/C) 20-90% relative humidity, non-condensing: 5° to 40° C | 41° to 104° F
- Regulations: Complies with EN60950, FCC Class A, CISPR22/85, EC, EU RoHS, TAA Compliant
- Diagonal Size: 55 inches (1397mm)
- Tiled bezel width (min.) : 0.88 mm or better
- Brightness (maximum) : 500 candelas or nits
- Response time (typical) : 8ms or better
- Colors : 16.7 million
- Backlight type : LED
- Backlight life (1/2 brightness) : 50,000 Hrs
- Heat load (Typical) : 700 BTU per hour
- Backlight control : Individual and wall control
- Power consumption: 146 watts per panel (Typical)

(B) 98” Interactive displays

- 24-hour advanced exchange policy: The display manufacturer must offer a service policy that allows a replacement LCD to be shipped out within 24 hours.
- Multi-Touch support: An integrated 20-point touch system must be available with the display. Touch Overlays are not acceptable.
- Diagonal Size: 98 inches
- Resolution: 3840x2160
- Aspect ratio (W:H) : 16:9
- Technology: Commercial-grade direct-lit LED LCD
- Brightness (maximum) : 400 candelas or nits
- Response time (typical) : 8ms or better
- Dynamic contrast ratio (full field) : 20,000:1 or better
- Full viewing angle : 178°
- External connections: DisplayPort 1.2 x1, HDMI 2.0 x2, HDMI 1.4 x2,
- Support for 4K @ 60 Hz content
- HDCP 2.2 compliant
- Colors : >1 billion. Full 10 bit data path
- Color gamut: 72% NTSC or better
- Multi-Source view: Quad only
- Display control: IR, RS-232, LAN, Keypad
- Backlight type : LED
- Backlight life (1/2 brightness) : 50,000 Hrs
- Support for both landscape and portrait orientation
- Speakers: 10W x 2 built-in or better
- Acoustic noise : Fan-less operation
- Heat load: 1402 BTU per hour
- Operating temperature range : 0°-35°C
- Operating humidity range : 20-85% RH non-condensing
- Calibration control : by input (up to 6 inputs)
- Image adjustment: by input (up to 6 inputs)

- Power consumption : 410 watts (Typical)
- Power supply voltage: 100-240V AC, 50 to 60 Hz
- Mounting: VESA compatible
- Power status: Diagnostics LEDs, health monitoring and alerts via email

(C) Codec & camera:

- Smart meetings
 - Brings intelligent views to medium to large-sized rooms with discreet, integrated cameras
 - Best overview: Automatically detects meeting participants and provides ideal framing
 - Speaker tracking: Detects and switches between active speakers and provides ideal framing
 - 6-element microphone array for accurate speaker tracking
 - 5K Ultra HD camera array
 - Great audio experience with integrated speakers and microphones (microphones for speaker tracking only)
 - Automatic noise suppression reduces disruptive sounds coming from the meeting room (e.g., typing, paper rustling)
 - Simplified meeting-join experience with One Button to Push (OBTP) for scheduled devices in a meeting, whether registered on-prem or to the cloud
 - Automatic wake-up: System “wakes up” when someone walks into the room, and recognizes them through their mobile device
 - Easily controlled by a UI control unit or with an app
 - End-to-end security
- Smart presentations
 - Supports dual screens for video and content
 - Supports dual content sources for local meetings
 - 4K content sharing (local 30 fps; remote 5 fps)
 - Wired or wireless content sharing
- Smart rooms
 - Metrics: Counts people in the room, enabling analytics for better resource planning
 - Automatic screen/display integration through HDMI CEC
 - Supports Wi-Fi
 - In-room control: Control peripherals such as lights and blinds through the Cisco Touch 10
- Built for cloud and premises
 - Flexibility to register on the premises or to the cloud
 - Hardware is optimized to run on a cloud platform, for great experiences in shared rooms and spaces with easy access to hosted conferences

(D) Audio

- Conference table top beam-tracking microphones for video or audio calls
 - Low profile circular ceiling mic that measures only 5.75 inches (146 mm)
 - Mounts directly to the ceiling to virtually disappear in room
 - Beam-tracking technology actively tracks and intelligently mixes conversations

- Four 90-degree zones for full 360-degree room coverage
- Network box which includes DSP for Beam-tracking
- Uses only one channel of AEC per mic
- Single cable connection via CAT cable
- Beam-tracking technology works out-of-box without any lobe aiming or room mapping
- LED mute status indicator
- Available in either black or white
- Evaluated to the requirements of UL 2043 and is suitable for use in air handling spaces
- Additional RJ-45 connection
- CE marked, UL listed, and RoHS compliant
- Covered by manufacture five-year warranty
- Ceiling speakers for even dB coverage throughout the environment
 - Full-Range Flat Field Speakers with Low Profile Enclosure and 70/100 V Transformer
 - 2' x 2' (61 cm x 61 cm), 7.8 lb (3.5 kg) drop-in ceiling tile speaker designed for US style suspended ceilings
 - UL 2043 plenum rated enclosure
 - Patented Flat Field Technology for consistent sound levels across the listening area, reducing the number of speakers required
 - 3" (76 mm) horn-loaded, full-range driver provides extended low frequency reproduction
 - White perforated grille matches appearance of air conditioning vents
- Digital Signal Processor (DSP):
 - Integrates VoIP, POTS, and USB audio into one product allowing integrators to choose the type of audio conferencing that works best for their installation
 - AVB allows audio networking via IEEE open standards protocol
 - Includes default configuration file, allowing for plug-and-play usage
 - Highly scalable and cost-effective solution that can grow over time with the needs of the customer
 - Speech-Sense technology to enhance speech processing
 - Integrates directly with soft codecs and other USB audio hosts
 - 128 x 128 channels of AVB
 - 12 mic/line level inputs; 8 mic/line level outputs
 - 12 channels of AEC
 - Gigabit Ethernet port
 - Up to 8 channels of configurable USB audio
 - RS-232 serial port
 - 4-pin GPIO
 - 2-line OLED display with capacitive-touch navigation
 - Rack mountable (1RU)
 - System configuration and control via Ethernet
 - Internal universal power supply
 - SIP VoIP interface via RJ-45 connector
 - Standard FXO telephone interface via RJ-11 connector
 - Fully compatible with Tesira AVB servers, endpoints, expanders, and controllers

- Signal processing via intuitive software allows configuration and control for signal routing, mixing, equalization, filtering, delay, and much more
- CE marked, UL listed, and RoHS compliant
- Covered by vendor 5-year warranty

(E) Video processing integrated control system:

- Graphical User interface must provide a “Live Preview”, allowing users to preview thumbnails of video content on the UI before sending to the wall.
 - Control of third-party devices such as VTC Systems, audio devices, cable tuners, Apple TV, and IP cameras directly in the same user interface requiring no external hardware, custom programming, and remote controls.
 - Available three tiered Enterprise Architecture:
 - Video wall processor with preinstalled software.
 - Hosts multiple web applications as content sources reducing the need for individual workstations and eliminating the impact of performance degradation on the video wall processor. (See attachment for more details on this technology which is completely unique to this manufacture)
 - Real time processor failover providing essential functions such as display of IP based content and control of external systems.
 - Streaming of entire video wall to multiple sites across the network with no corresponding performance degradation
 - Secure architecture including:
 - 168-bit Triple Data Encryption (3DES) using three individual 56-bit keys. Additionally, data sent between your browser and web server is encrypted via Secure Sockets Layer (SSL).
 - Single sign on with SAML integration
 - Granular permission settings - Restrict users from specific content, rooms, connected devices, and pre-defined layouts.
 - Unlimited layouts and automated layout sequencing via a simple configuration user interface requiring no custom programming.
 - Ability to set ordering of overlapping assets (referred to as z ordering).
 - Annotations for real time collaboration.
 - Rest API – All video wall software functionality is based on microservices and underlying APIs for ease of integration with external applications.
- 24x7 mission critical customer support model

Pay Item

Pay Unit

Central Video Equipment

Lump Sum

16. SYSTEM INTEGRATION

16.1. GENERAL

The Contractor shall integrate the Phase III equipment, components, assemblies and materials with the existing City of Alexandria ITS CCTV System. The Contractor shall be responsible for ensuring that all selected equipment, components, assemblies and materials are fully functional with the existing system and shall be completely interoperable with all previously installed hardware, software, and control systems.

- The primary components of the Phase III project include:
 - Installation of single-mode fiber-optic cable and conduit communications network. New fiber optic cable along with the conduit or new fiber in the existing conduit/duct will be installed;
 - Video surveillance system with 11 CCTV cameras;
 - Linking of the existing traffic signal cabinets to the fiber optic communication cable system using Passive Optical Network (PON) technology. A total of fifty-eight (58) intersections will be connected to the signal system via fiber-optic network;
 - Expansion of the TMC video wall include installation of fifteen (15) LCD monitors on the west side and one (1) jumbo LCD monitor on the north side of the TMC;
 - Central site (TMC) video equipment and software; and
 - Conditions map workstation system

Phase III shall provide, install and integrate additional fiber optic communication cable with corresponding conduit/duct, junction boxes, fiber optic splice centers, modification of existing cabinet foundations, CCTV cameras and associated cable and interconnect hardware at nine locations, eleven communications edge switches, ethernet switch between ONT and router, and four field termination cabinets.

The Phase III Contractor shall be fully responsible for any damage to existing infrastructure, equipment, cabling, or utilities installed and being utilized by the City of Alexandria. The Phase III Contractor is advised to use the upmost of care if digging around existing cabinet bases or in areas where conduit/duct and fiber optic cable have been installed previously.

In the event any equipment, materials, or resources are damaged by the Phase III Contractor, the City of Alexandria Project Manager and/or City Engineer shall be immediately notified of the incident and the extent of the damage. The Phase III Contractor shall also provide to the Engineer in writing an estimate of the work to be performed to repair the damage and estimated timeline for full restoration.

16.2. CONDITIONS MAP WORKSTATION SYSTEM

The Workstation System shall be designed using off-the-shelf hardware and software to the maximum extent possible. The application programs and servers shall use industry-standard programming languages and databases, and shall run under operating systems using industry-standard interfaces to the applications.

(A) Equipment

The Contractor shall provide and install workstation system that are current model and shall include server, two (2) 24" LED monitors, keyboards, mouse and accessories. The supplied workstation system shall have sufficient processing power to meet or exceed all performance requirements of this

specification, as listed below. The Contractor proposed monitoring and management software and architecture shall not restrict the workstation components to a single manufacturer, such as HP, DELL, etc. It shall be possible for City of Alexandria to upgrade workstation components in the future with those from a different manufacturer as that of the originally supplied component as long as the replacement component specifications meet or exceed those of the original.

(B) Software

The Contractor shall supply complete tools and all necessary files for managing, building, and testing software. Facilities shall be provided to support building and testing without impacting 24/7 operations. Contractor-supplied updates to the system software provided after initial installation shall also include any necessary updates to the software maintenance tools in order to keep the maintenance tools valid and usable for the currently installed version of the system software. All maintenance software shall execute without interfering with the online system.

(C) TMC integration

The Contractor shall provide necessary hardware, software and wiring needed to display conditions map onto video wall and consoles in TMC via KVM switch.

(D) Security

The Contractor shall provide the firewall and coordinate with the City of Alexandria IT Department and Traffic Division for establishing network security for the workstation system.

16.3. PROCEDURES

The Phase III Contractor shall be responsible for updating the central video equipment database (CCTV list and map) with new CCTVs installed in Phase III.

Phase III contractor shall be responsible for bringing the feed for the condition map to a dedicated workstation in the Traffic Control Center by connecting to IT server. Workstation System shall have the capability to display conditions map on to video wall and consoles in TMC via KVM switch.

16.4. MEASUREMENT AND PAYMENT

The System Integration will be measured and paid as a lump sum upon successful acceptance of the central video equipment database (CCTV list and map) update with new CCTVs installed in Phase III.

Separate payment will be made by the City of Alexandria for CCTV dome camera installations and for fiber optic cable and conduit installation, however no other payment will be made for the system integration of the Phase III equipment and materials.

The Conditions Map Workstation System will be measured and paid as a lump sum upon successful acceptance of displaying conditions map on the video wall and consoles in TMC.

Pay Item	Pay Unit
Phase III System Integration	Lump Sum
Conditions Map Workstation System	Lump Sum
KVM switch	Each

17. SUBMITTAL DATA

17.1. DESCRIPTION

Provide project documentation as described below.

17.2. SUBMITTALS

(A) General

All documentation shall be either 11" x 17" or 8½" x 11" format. No documentation may be smaller or larger than these formats. All submittals will be reviewed and approved by the City. Absence of comment will not grant approval.

The Contractor shall submit documentation 28 days prior to work described therein. The City shall review and provide comments within 21 days of receiving Contractor submissions.

(B) Project Construction Schedule

Prepare and submit for approval by the Engineer a schedule of the proposed working progress on the project in accordance with the instructions and on forms furnished by the City. Update and submit the schedule monthly.

The project schedule shall include a monthly schedule of values. At the end of each calendar month shown on the schedule, show a value (in dollars) of the cumulative project work projected to be completed. The proposed project schedule shall be submitted no later than 7 days prior to the date of the project preconstruction conference and shall be approved before any work is begun on the project.

When conditions beyond the Contractor's control have adversely affected the Contractor's progress, or the City has extended the completion date, the Contractor may submit a revised progress schedule to the City for approval. Such revised progress schedule will not be approved unless accompanied by a detailed written statement giving the Contractor's reasons for the proposed revision.

The project construction schedule shall show at least:

- Major Activities,
- Critical Path,
- Task Dependencies,
- Float Time for Each Task,
- Project Start and Completion,
- Task Durations,
- Task Begin and End Dates,
- Milestones,
- Material Submittals,
- Submittal Review Periods,
- Equipment Deliveries,
- Sample and Material Testing,
- Acceptance and Demonstration Testing,

- Training,
- Observation Period,
- Final Acceptance

(C) Qualified Products

The Contractor shall furnish new equipment, materials, and hardware unless otherwise required. The Contractor shall inscribe manufacturer's name, model number, serial number, and any additional information needed for proper identification on each piece of equipment housed in a case or housing.

The Pre-Approved Traffic Control Device Listing (PATCDL) is available on the Virginia Department of Transportation's Website. Certain communications equipment, material, and hardware shall be pre-approved on the PATCDL by the date of installation. Equipment, material, and hardware not pre-approved when required will not be allowed for use on the project. Consult the PATCDL Website to obtain pre-approval procedures.

(D) System Design Report

The Contractor shall prepare a System Design Report to describe the proposed modifications to the network architecture and its configuration. The report shall provide a project timeline. The report shall provide a detailed description of the hardware and software to be installed. The report shall depict and describe the entire layout of the equipment and their connectivity. Provide a detailed listing of the hardware including brand and model numbers, functions and descriptions. Provide a detailed listing of the VLAN configuration and IP addresses.

The Contractor shall submit the report and obtain approval before providing material submittals for the following packages of items as described below: central video equipment, software, computer hardware, and communications equipment.

(E) Submittal Requirements

The Contractor shall provide written certification to the City that all Contractor-furnished material is in accordance with the contract. When requested by the City, provide additional certifications from independent testing laboratories and sufficient data to verify item meets applicable specifications. The Contractor shall ensure additional certification states the testing laboratory is independent of the material manufacturer and neither the laboratory nor the manufacturer has a vested interest in the other.

The intent of submittals is to show completely that the materials meet the requirements of the Plans and Project Special Provisions and how the Contractor intends to construct or configure the materials. The Contractor shall clearly demonstrate in the submittals that the desired materials shall meet or exceed the requirements of the Plans and Project Special Provisions. Each submittal shall be sufficiently complete and detailed for the City to review and approve the submittal. If the City deems the submittal insufficient in detail or completeness for review or approval, the submittal will be returned as rejected. Additional time will not be granted for resubmittal.

Before material submittal data begins, provide to the City a list of all submittals with approximate dates of submission that the Contractor intends to make. It is incumbent upon the Contractor to schedule reviews in a timely manner that will not delay this schedule. Allow the City a 21 calendar day review time.

Certain groups of materials are related in function and operate as a subsystem together. To ensure individual and subsystem compliance with the project requirements materials shall be submitted as packages as follows:

Submittal Package	Description
Fiber-optic Cable	Fiber-optic Cable, Pre-Terminated Drop Cables, Interconnect Centers, Delineator Markers, Tracer Wire, Active Splice Enclosures, PON Splice Enclosures
CCTV Equipment	Hybrid Camera Cable, CCTV camera
PON Equipment	PON Drop Cable, PON Splitter
Computer Hardware	Network Management Server, Laptop Computers (see “Computer Hardware” section of these Project Special Provisions for further requirements)
Video Wall Equipment	Video wall, 98” interactive display, camera, codec (see “Video Wall Equipment” section of these Project Special Provisions for further requirements)
Conditions Map Equipment	Server, monitors, peripherals, KVM switch (see “Systems Integration” section of these Project Special Provisions for further requirements)
Communications Equipment	OLT, ONT, Ethernet Edge Switches (see “Communications Hardware” section of these Project Special Provisions for further requirements)
Field Infrastructure	Conduit, Junction Boxes, Modify Junction Boxes, Remove Junction Boxes, Electrical Service Equipment (Disconnects, Meters), Grounding Electrodes, Termination Cabinets, Cabinet Foundations, Modify Cabinet Foundations, and Misc. Hardware

The Contractor shall identify all proprietary parts in Contractor-furnished material. The City reserves the right to reject material that uses proprietary components not commercially available through electronic supply houses.

For Contractor-furnished material listed on the PATCDL, the Contractor shall furnish submittals in the format defined by the PATCDL.

For Contractor-furnished material not on the PATCDL, the Contractor shall furnish three copies of the equipment list including three copies of catalog cuts. Identify proposed material on catalog cuts by a reproducible means (highlighter pen does not transfer to copies). The Contractor shall ensure material lists contain material description, brand name, manufacturer’s address and telephone number, stock number, size, identifying trademark or symbol, and other appropriate ratings. For submittals showing a

variety of models and parts available from the manufacturer, clearly identify by circles, marking our other means the specific materials for which approval is requested.

Allocate 21 days for the City to review and respond to a submittal. The Contractor shall not deviate from what is approved without approval by the City. The Contractor shall not fabricate or order material until receipt of the City's approval. All submittals shall be returned as either "Approved (as submitted)", "Approved as Noted" or "Rejected". The Contractor may proceed with fabrication or ordering for items marked "Approved". If an item is marked "Approved as Noted" without any stipulation for resubmittal, then the Contractor may proceed with fabrication or ordering. For any other notations, the Contractor shall revise the submittal, address comments and resubmit for approval.

17.3. MEASUREMENT AND PAYMENT

There will be no direct payment for work covered in this section. Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this section.

18. TRAINING

18.1. DESCRIPTION

The Contractor shall provide training for the installation, operation and maintenance of equipment installed in Phase III but that was not provided in Phases I or II.. Additionally, the Contractor shall provide training for the installation, operation and maintenance of equipment that was installed during Phase III that does not match the make, model and version of the same equipment installed during Phase I or II.. Such equipment may be the following:

- Ethernet edge switch
- CCTV field equipment,
- TMC Video Wall and Equipment Utilization,
- PON Communication on OLT and ONT

The City reserves the right to eliminate or scale down training based upon the equipment selected for Phase III.

18.2. MATERIALS

(A) General

The Contractor shall provide training in the installation, operation, maintenance, troubleshooting, and repair of all equipment and software. The Contractor shall prepare training outline, agenda, training manuals, training exercises, instructor resumes and any other teaching aids for approval by the City. For exercises requiring computers, the Contractor shall furnish enough computers to have one computer per two students.

The Contractor shall provide all laptop computers, projectors and projector screens needed for the training. The Contractor shall provide all audiovisual equipment needed for presentations and demonstrations, including video players. The Contractor shall provide a test cabinet for use during the training. The Contractor shall provide all power cords, extension cords, power strips and other cables required for the equipment used in the training shall be provided.

Three days of training shall consist of two 4-hour training sessions per day.. There shall be two 15-minute breaks per training session.

The Contractor shall provide draft-training material to the City for review and approval at least 60 days prior to the scheduled training. The Contractor shall provide adequate time for review and revision of the draft training materials. The Contractor shall furnish all audio-visual equipment, demonstration equipment, and "hands-on" equipment in support of the envisioned training. Each training participant shall receive a copy of course materials including both comprehensive and presentation manuals. Assume there shall be a maximum of 10 students in each class session. The Contractor shall provide two additional copies of these documents to the City.

The Contractor shall utilize training personnel well versed in the subject matter and with extensive field experience dealing with real world problems. Utilize training personnel that are certified by the respective manufacturers.

The Contractor shall video record all classroom and hands-on demonstrations and training in clear, understandable volumes on digital video disc (DVD) and provide two (2) DVD(s) to the City for their use.

The training shall be conducted locally after the completion of all system integration tests. The City shall provide the training facility. The Contractor shall provide the City with a 30-day notification to carry out the training so that arrangements can be made for attendance. Coordinate a mutually agreeable date, time and location with the City through the Engineer. The Engineer shall approve the training schedule time and location.

The Contractor shall develop the course content specifically for the products supplied for this project. The course shall include the following topics:

- Introductory-level briefing to familiarize attendees;
- Terminology;
- Theory of operation;
- Installation;
- Hardware and software configuration;
- Operating procedures and capabilities;
- Testing, diagnostics and troubleshooting;
- Software applications;
- Use of the system documentation to operate, diagnose, maintain, and expand the system; and
- “Hands-on” use of the system, and software, system test equipment, and any other system equipment supplied.

The Contractor shall provide course lengths as follows:

Course	Type of Training	Total Students	No. of Sessions	Length (Days)
Ethernet Edge Switches	Lecture and Hands-on Exercises	6	1	1
CCTV Field Equipment	Lecture and Hands-on Exercises	6	1	1
TMC Video Wall and Equipment Utilization	Lecture and Hands-on Exercises	10	2	1
PON Communication on OLT and ONT	Lecture and Hands-on Exercises	6	2	1

Provide additional specific training as described below.

(B) Ethernet Edge Switches

The Contractor shall provide the test and repair equipment used in the training. Contractor shall cover Ethernet Switch programming that is new to the latest version of switch firmware that is not adequately conveyed in current manuals.

Provide training for the Ethernet edge switches for the following categories and for the minimum length of time shown:

Course	Type of Training	Length (Days)
Ethernet Switches		0.5
Introduction	<u>Lecture</u>	
Configuration and programming	<u>Lecture and Hands-on</u>	
Review of Maintenance Manual	<u>Lecture and Hands-on</u>	
Review of Operations Manual	<u>Lecture and Hands-on</u>	
Maintenance	Lecture, Demonstration and Hands-on	
Routine		
Troubleshooting procedures		
Testing		
System restart and recovery		
Question and answer session		

(C) CCTV Field Equipment

Contractor shall cover camera programming that is new to the latest version of camera firmware that is not adequately conveyed in current manuals. The Contractor shall provide training for the CCTV field equipment and the local CCTV camera software as described below:

Course	Type of Training	Length (Days)
Operations	Lecture	0.5
Theory of Operation	Lecture, Demonstration	
Local camera programming	Lecture, Demonstration and Hands-on	
Camera addresses		
Other Key features		
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

18.3. MEASUREMENT AND PAYMENT

Training will be measured and paid at the contract lump sum price. The price and payment will be full compensation for all work required by this section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
CCTV Training	Lump Sum
PON Communications Training	Lump Sum
Ethernet Edge Switches Training	Lump Sum
TMC Video Wall and Equipment Utilization Training	Lump Sum

19. TESTING AND ACCEPTANCE

19.1. GENERAL

The Contractor shall conduct and complete successfully the following progressive series of tests before acceptance:

- Field demonstration test prior to installation,
- Installed standalone tests,
- System test of the network hardware,
- Network management software and an operational test.

The Contractor shall develop a comprehensive series of test plans for each device to determine if the equipment was correctly installed and meets the project requirements set forth at the initiation of the project, and requirements of the materials, workmanship, performance, and functionality required in the plans and project special provisions. The test plans shall describe the functions to be tested, purpose of test, setup requirements, procedures to be followed, any inputs and expected outputs for each test, criteria for pass/fail and any required tools or test equipment. Any software testers shall be pre-approved by the City.

The Contractor shall develop as part of the Test Plan a Traceability Matrix of all the individual subsystem functional requirements to be used to cross-reference each planned test to a specific contract requirement to be verified. This Test Evaluation/Traceability Matrix shall be used by the Engineer to crosscheck the functional requirements and the results.

A key element of test plans, where appropriate, shall be the introduction of forced errors into the functional test. The test plan shall check the actual result of the forced error against the anticipated result. Test shall be performed by the Contractor and witnessed by the City. No deviation from the written test procedure shall be permitted without approval from the Engineer. Any changes to the approved test procedure to accommodate unforeseen events during the time of testing shall be documented in a copy of the master test procedure. Immediately following the conclusion of each test, the City and the Contractor shall meet to agree on the results observed and recorded during the testing. This shall form the basis for the conclusions reported in the test plan. All test results, notes, and observations shall be maintained in both electronic and hard copy. Maintain complete records of all test results during all stages of testing

Contractor test plans shall be submitted at least 45 calendar days prior to the planned test date. Once the test plans are approved by the City, the Contractor shall provide the City 15 calendar days advance notice of any planned test as directed by the Contract Documents. The notice shall clearly identify the type of test and exact location(s) of the equipment to be tested.

The Contractor shall provide all test equipment required for the field demonstration and installed standalone tests. All test equipment used for project testing shall have a calibration sticker or certificate, a copy of which shall be provided to the City with the appropriate test plan where utilized. The calibration sticker or certificate shall be dated within the year used for the testing, and shall be traceable to either NIST or ISO calibration standards.

19.2. PRE-INSTALLATION FIELD DEMONSTRATION TEST

The Contractor shall conduct a pre-installation test of the Phase II CCTV cameras and Ethernet edge switches at a Contractor-provided facility within the city limits of Alexandria. The Contractor shall perform the test to demonstrate that the functional requirements of the CCTV cameras and communications hardware have been met. Notify the Engineer a minimum of 15 calendar days before the start of the test.

If the pre-installation test cannot successfully demonstrate the full functionality of the system, the Contractor shall correct the deficiencies and repeat the test until successful.

The Contractor shall prepare a report and deliver that report to the Engineer documenting the findings of the demonstration. The report shall describe the nature of the failure and the corrective action taken.

If a failure pattern develops (more than two failures), the Engineer shall make a determination of the disposition of the failed test without additional cost to the City or an extension of the contract period.

19.3. INSTALLED SITE TESTS

The Contractor shall conduct an approved, standalone equipment installation test at the field site. All standalone functions of the field equipment shall be tested using equipment installed as detailed in the plans, or as directed by the Engineer.

The Contractor shall complete approved test plan forms and turn them over to the Engineer for review as a basis for rejection or acceptance. Provide a minimum notice of 15 calendar days prior to all tests to permit the Engineer or his representative to observe each test.

If any unit fails to pass its stand-alone test, the Contractor shall correct the unit or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a standalone test failure, the Contractor shall prepare a report describing the nature of the failure and the corrective action taken and deliver it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that design and construction modifications shall be made to all units without additional cost to the City or an extension of the contract period.

The Contractor shall utilize vendor supplied device software to perform diagnostic tests of each device. The vendor supplied diagnostic software shall be provided to the City before final acceptance. The Contractor shall test the following features of each competent as described below.

(A) Fiber-Optic Cable

The Contractor shall conduct optical time domain reflectometer (OTDR) tests on all fiber optic cable on the reel and after the cable is installed but prior to any terminations. These tests confirm the integrity of the fiber prior and after installation and can be performed unidirectional. The Contractor shall provide written notification a minimum of fifteen days before beginning fiber-optic cable testing. A City representative shall be present during the cable reel and post-installation tests.

The Contractor shall perform bi-directional OTDR loss tests on all unused fibers installed in this phase of the project

After splicing is completed, the Contractor shall perform bi-directional OTDR tests on each fiber to be used to ensure the following:

- Fusion splice loss does not exceed 0.1 dB,
- Terminations and connections have a loss of 0.5 dB or better,
- Reflectance is -50dB or better for each UPC connector, and
- Reflectance is -60dB or better for each APC connector.

The Contractor shall install a 1000-foot pre-tested launch cable between the OTDR and fiber-optic cable to be tested.

If the OTDR shows that the splice loss budget is exceeded, the Contractor shall remake splices until the loss falls below 0.1 dB. The City shall record each attempt for purposes of acceptance.

Test shall be performed for both 1310 and 1550 nm wavelengths on the fiber optic cable.

The Contractor shall furnish durable labeled plots and electronic copies on a CD or DVD of test results for each fiber including engineering calculations demonstrating that OTDR test results meet or exceed the attenuation requirements and that optical properties of the cable have not been impaired. Clearly label each OTDR trace identifying a starting and ending point for all fibers being tested.

The Contractor shall provide engineering calculations and tests for fiber-optic cable that demonstrate the loss budget where the fiber originates and where the fiber meets an electronic device. The calculations shall summarize the optical losses versus the allowable losses for the communications equipment between each pair of communications hardware. The Contractor shall provide a summary section or spreadsheet with a labeled tabular summary showing each test segment with begin and end points and actual versus allowable losses. Label the manufacturer's make, model number and software version of the OTDR used for testing.

The Contractor shall furnish one hard copy of each of the OTDR trace results and electronic copies of all trace results on a CD or DVD.

If any fiber exceeds the maximum allowable attenuation or if the fiber-optic properties of the cable have been impaired, the Contractor shall take approved corrective action including replacement of complete segments of fiber-optic cable if required. Corrective action shall be at no additional cost to the City and as directed by the Engineer.

(B) Ethernet Communications System

(1) Laptop Computers

The following operational tests shall be performed for the laptop computers in accordance with the test plans. After the equipment has been installed:

- Connect all components (displays, mice, keyboards, network cables, power supplies),
- Configure network communications,
- Map network drives,
- Test connections to all devices by pinging,

- Run diagnostic utilities on the hardware, and
- Map all network servers.

(2) Ethernet Switches

The Contractor shall conduct local field acceptance tests of the Ethernet edge switch field site according to the submitted test plan. The Contractor shall perform the following:

- Verify that physical construction has been completed as detailed in the Plans,
- Inspect the quality and tightness of ground and surge protector connections,
- Verify proper voltages for all power supplies and related power circuits,
- Connect devices to the power sources,
- Verify all connections, including correct installation of communication and power cables, and
- Perform testing on multicast routing functionality if Ethernet switch not from City- approved vendor.

The Contractor shall repair or replace defective or failed equipment and retest. Upon satisfactory completion of operational test, The Contractor shall begin an Observation Period of 60 days prior to system acceptance.

(C) CCTV Field Equipment

The Contractor shall develop an operational test plan that demonstrates all requirements of the equipment and software. The Operational Test Plan shall be submitted for approval before conducting tests.

Notify the City at least 15 calendar days prior to the proposed date for the tests. The City shall have the right to witness such tests, or to designate an individual or entity to witness such tests.

The Contractor shall perform the following local field operational tests at the camera assembly field site in accordance with the test Plans. A laptop computer shall provide camera control and positioning. After completing the installation of the camera assembly, including the camera hardware, power supply, and connecting cables, the Contractor shall:

- Furnish all equipment, appliances, and labor necessary to test the installed cable and perform the following tests before any connections are made,
- Verify that physical construction has been completed,
- Inspect the quality and tightness of ground and surge protector connections,
- Check all power supply voltages and outputs,
- Connect devices to the power sources,
- Perform continuity tests on the surveillance camera's stranded conductor element using a meter having a minimum input resistance of 20,000 ohms per volt and show that each conductor has a resistance of not more than 16 ohms per 984.3 feet of conductor;
- Measure the insulation resistance between the conductors, and between each conductor, ground, and shield using a Megger® meter. The resistance shall be infinity. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronics or field devices; and

- Replace any cable that fails to meet these parameters, or if any testing reveals defects in the cable, and retest new cable as specified; and
- Verify installation of specified cables and connections between the camera, PTZ, camera control receiver, and control cabinet,
- Perform the CCTV assembly manufacturer's initial power-on test in accordance with the manufacturer's recommendation,
- Set the camera control address,
- Verify the presence and quality of the video image in the field cabinet with a portable
- NTSC-approved monitor or laptop computer
- Exercise the pan, tilt, zoom, focus, iris opening, and manual iris control selections, and the operation, preset positioning, and power on/off functions,
- Demonstrate the pan and tilt speeds and extent of movement to meet all applicable standards, specifications, and requirements,
- Interconnect the communication interface device with the communication network's assigned fiber-optic trunk cable and verify that there is a transmission LED illuminated.

Test the grounding system per ANSI/IEEE C62.41 and ANSI/IEEE C62.45 as applicable. The Contractor shall measure the ground impedance utilizing an instrument designed specifically to measure and document the ground impedance. The Contractor shall provide written test results of the ground impedance for each location to the engineer prior to backfilling the grounding electrode. The test results shall include the instrument model, date of instrument calibration, and local environmental conditions at the time of testing. Certify and sign the test results by the Contractor.

The Contractor shall repair or replace defective or failed equipment and retest

19.4. SYSTEM TESTING

(A) General

The Contractor shall conduct tests as described below of the traffic signal and CCTV subsystems. The Contractor shall conduct approved device subsystem tests on the field equipment with the existing Alexandria TMC equipment including, at a minimum, all remote communications hardware monitoring and control functions. These tests shall be a demonstration of overall system stability. During this test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum of eight hours. The Engineer shall have the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of eight hours.

The Contractor shall conduct device and subsystem tests of any repaired or replaced equipment.

The Contractor shall display the event log from the CCTV software for a minimum of seven days. The Contractor shall complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance.

The Engineer shall have the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of eight hours. If a component has been modified as a result of a test failure, the Contractor shall prepare a report and deliver it to the Engineer prior to retesting.

(B) CCTV Subsystem

After completing the integration of the CCTV cameras into the CCTV subsystem software, the Contractor shall conduct a minimum of a seven-day test of the CCTV subsystem hardware and software. This shall include that portion of the communications network serving the CCTV subsystem. The Engineer shall have the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of eight hours. If during that time it is determined by the City there are hardware or software failures that are the responsibility of the Contractor, the Contractor shall make repairs or replacements to the satisfaction of the City.

Test the following features of each competent as described below.

(1) CCTV Field Equipment

The following items, not otherwise required to be tested elsewhere, shall be tested for each CCTV site from the Alexandria TMC:

- NTCIP objects,
- Power-up self-tests,
- Iris control,
- Preset functions,
- Presence and quality of the video image,
- Preset positioning, and power on/off functions,
- Camera and controller access and security from all workstations,
- Disconnect camera and take local control and reconnect camera at local cabinet to the communications and verify Alexandria TMC control is regained,
- Confirm ability to change camera ID,
- Verify unique camera identifier and icons on GUI,
- Viewing of camera image on each monitor.

(2) CCTV Central Equipment

The Contractor shall verify that all CCTV images from the Phase III CCTV cameras can be displayed correctly on each monitor using the Phase III Video Wall Processor and the camera can be controlled through the existing BVMS software..

(3) CCTV Central Software

The Contractor shall thoroughly test all functions of the Phase III CCTV cameras with the existing software from the Alexandria TMC to ensure correct operation. Test the components of the CCTV central equipment from the Alexandria TMC as follows:

- Use the GUI interface to select and view each camera,
- Use and the GUI interface to test the ability to control the pan-tilt-zoom and iris settings of each camera,
- Use the GUI interface and test the ability to select and place any camera on any monitor,
- Use the image capture software to test the ability to capture video images.

19.5. TESTING AND INSPECTION

In addition to the test requirements defined in Section 19, the Contractor shall perform and be responsible for the System Integration Test. The purpose of this test is to verify that the Phase III project installation and integration operates as a complete, integrated system in accordance with the requirements of these specifications.

These tests shall be conducted primarily from the TMC, with the system being observed on the TMC video wall from all of the Phase III CCTV cameras and if necessary, by observers in the field.

The Phase III Contractor shall provide, in addition to other test requirements in this document, a System Integration Test Plan/Procedure that shall demonstrate full interoperability of the Phase III equipment and materials with the existing system. The System Integration Test Plan must be submitted in writing at least 45 days prior to the test period.

The System Integration Test shall be run from the TMC for a full 15 working days with no failures of any equipment or materials supplied by the Phase III Contractor. Any failure will be cause for the re-start of the test period.

19.6. OBSERVATION PERIOD

(A) General

A 60-day Observation Period shall begin upon the successful completion of the installed site tests and the system tests described in the preceding subsections as well as the correction of all known deficiencies, including minor construction items and punch-list items developed by the Engineer. During this period the City shall observe equipment and software operation to determine that all components of the fiber-optic communications system operate properly and interface with the traffic signal subsystem components and CCTV subsystem components according to the requirements of the Plans and these Project Special Provisions over an extended period of time.

During the Observation Period, the Contractor shall respond to failures of the Contractor's equipment within two hours and make repairs within eight hours. For items that pose a traffic safety hazard such as a controller failure, the Contractor shall make repairs within four hours. If any failures affect major system components for more than 48 hours, the City shall suspend the Observation Period beginning when the failure occurred. Resumption of the Observation Period shall start after successful repair or replacement. Failures of the following types shall cause the City to terminate the Observation Period and restart the Observation Period from zero once the failures have been corrected:

1. System or component failures that necessitate a redesign of any component; and
2. Three or more major system component failures of like nature within any 30-day period.

Major system components include:

- CCTV cameras and components;
- The fiber-optic communications network to include the Ethernet edge switches, the OLT and all ONTs; and
- The LAN and the Alexandria TMC computer equipment including the monitor walls.

Begin a new 60-day Observation Period with the approval of the Engineer after the faulty equipment has been repaired or replaced and the redesigned components have been installed.

A successful 60-day Observation Period shall consist of continuous operation with no more than a total of five calendar days of non-operation due to mechanical, electrical, or other malfunctions.

The Observation Period shall be completed by the project completion date and prior to final acceptance of the project. The Observation Period shall not begin until the both the CCTV and traffic signal subsystem tests have been successfully completed. The Observation Period shall not begin without the approval of the Engineer.

(B) CCTV Subsystem

During the Observation Period, the City will observe equipment and software operation according to the requirements of the Plans and these Project Special Provisions.

Major subsystem components shall include the CCTV cameras, all Ethernet switches, fiber-optic cable, and CCTV cabinets.

19.7. FINAL ACCEPTANCE

Final system acceptance shall be defined as the time when all work and materials described in the Plans and these Project Special Provisions have been furnished and completely installed by the Contractor; all parts of the work have been approved and accepted by the Engineer; and the CCTV system has been operated continuously and successfully for the 60-day Observation Period.

The project will be ready for final acceptance upon the satisfactory completion of all field demonstration, installed standalone, system, and operational tests. In addition, final acceptance shall not occur until all punch-list discrepancies have been rectified, all documentation has been delivered, and all required training has been completed.

Payment will be made under:

Pay Item

Pay Unit

Testing and Acceptance

Lump Sum